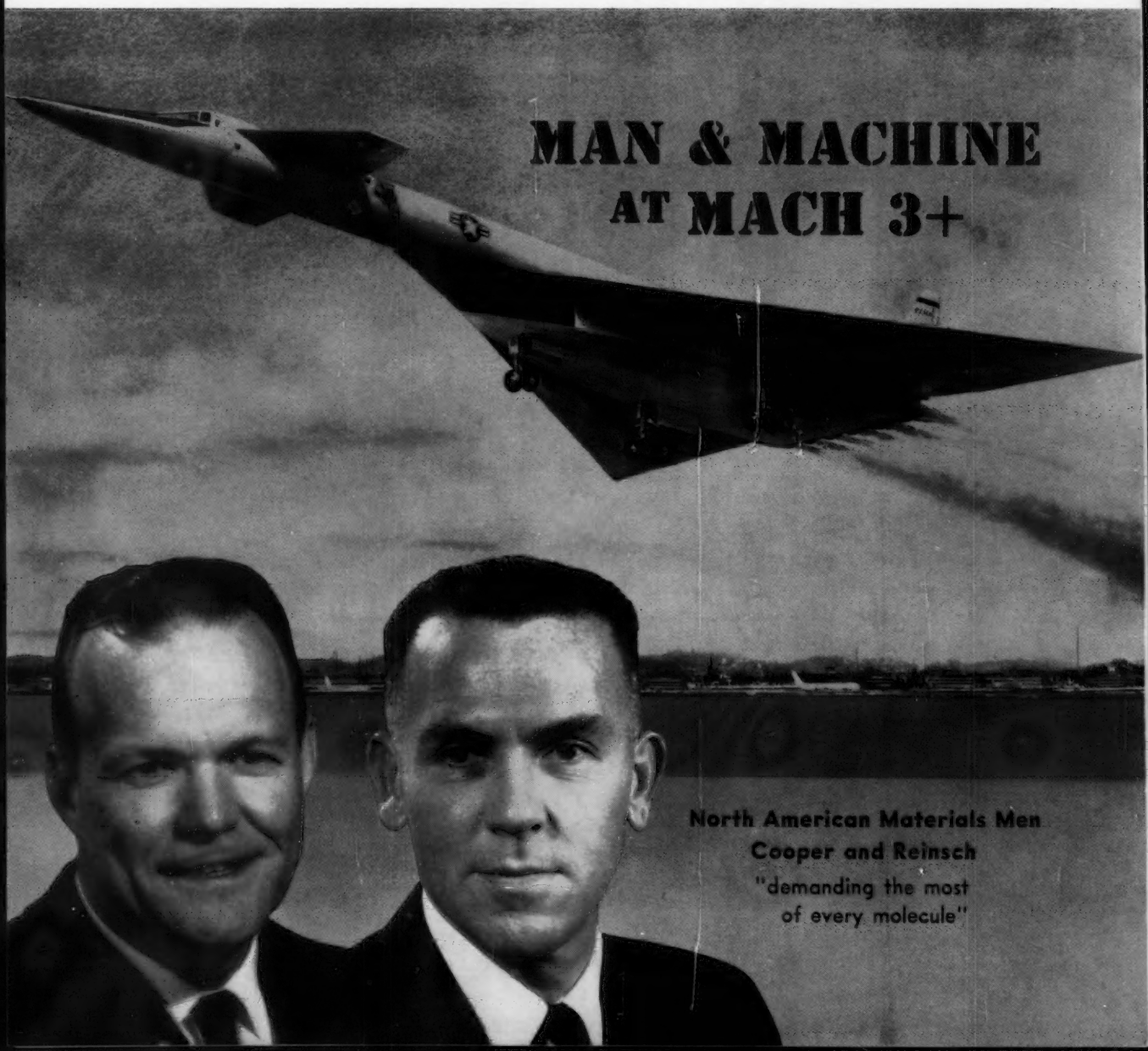
AIRCRAFT & MISSILES

A Chilton Publication APPLIED ENGINEERING FOR THE AEROSPACE INDUSTRIES JULY 1961

Mission For Management . . . How to Cut Costs In Logistics . . . P 44

The Challenge and The Progress—Supersonic Flight . . . P 25

Intelligence Report . . . RUSSIA—The Missiles They Have . . . P 51



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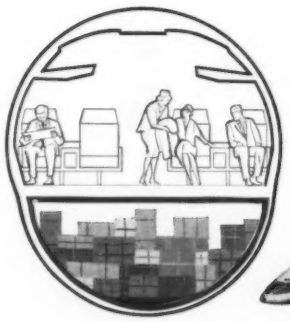

Cross section of the Boeing 727. Color outline shows High Modulus cargo liner.

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July, 1961 *Volume 4, Number 7*

AIRCRAFT & MISSILES

APPLIED ENGINEERING FOR THE AEROSPACE INDUSTRIES

Features

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Which materials and processes can management count on for 1965? 14.5—million engineering man-hours in B-70 show the way.

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NEXT MONTH

AEROSPACE ELECTRONICS AND PROPULSION—The biggest gap in our total space effort is still in propulsion. Many realized this from the very hour of Sputnik I on October 4, 1957. We are trying to get the most out of every ounce of payload we put in space. This puts great demands on electronics. New technologies are being born—bionics, molecular electronics, etc. The import and impact of new propulsion and electronic advances will be explored in this issue. SPECIAL SECTION: New products at WESCON.

Aerospace Data Capsule

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COMING IN SEPTEMBER

MARKSMANSHIP IN MANAGEMENT—"Bullseyeing" the right men to "sell" is often a difficult task in the complex aerospace industries. IN THIS ISSUE: How to gear your technical planning and marketing activities to mesh with the procurement patterns of Air Force, Navy, Army, NASA, and the weapon systems managers.

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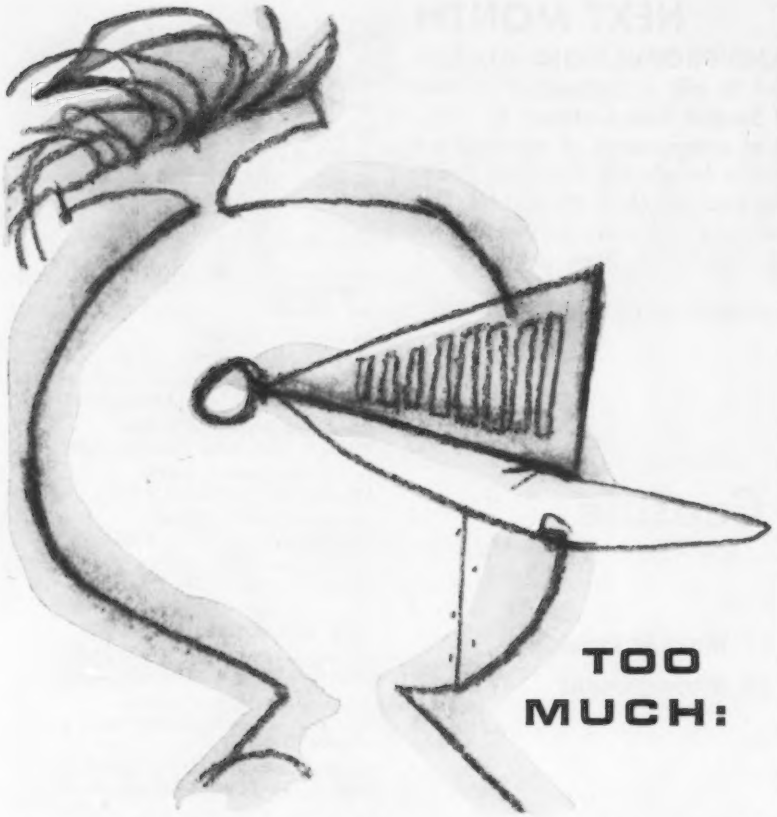
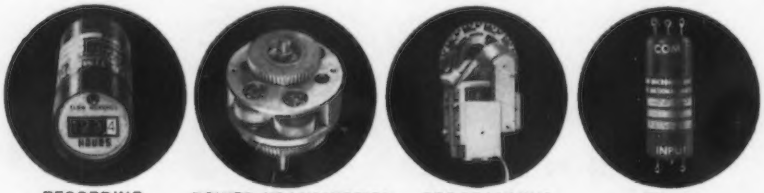


Cyrano didn't know the half of it! The problems that designers face nowadays, cramming increasingly complex equipment (and more of it) into smaller and smaller spaces would make a little nose bob job look simple. If you have such problems, why not call on Elgin Micronics? We specialize in precision sub-miniature component assemblies—mechanical, electro-mechanical or electronic—and we're organized for complete integration of our capabilities with yours. Our experience covers the full range of development from original concept, through research and engineering, to production.



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Dept. of Engineering
University of California
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Third Annual Industry Missile and Space Conference and Aerospace Exposition
Cobo Hall
Detroit, Mich.

July 17
Air Force Contract Aviation Services Symposium
Nat. Aeronautical Services Assn.
Hotel Washington
Washington, D. C.

July 18-20
Western Plant Maintenance & Eng. Show
Pan Pacific Auditorium
Los Angeles, Calif.

July 19-26
Symposium on Nomenclature of Organic Chemistry
Nat. Academy of Sciences
Columbus, Ohio

July 24-26
Air Traffic Control Facilities Symposium
Electronic Maintenance Eng. Assn.
Mayflower Hotel
Washington, D. C.

July 25-August 10
International Trade Fair and Aviation Exhibition
McCormick Place Exposition Center
Chicago, Ill.

August 1-3
Western Regional Meeting
American Astronautical Soc.
Sheraton-Palace Hotel
San Francisco, Calif.

August 7-9
Guidance and Navigation Conference
American Rocket Society
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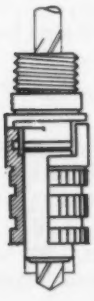

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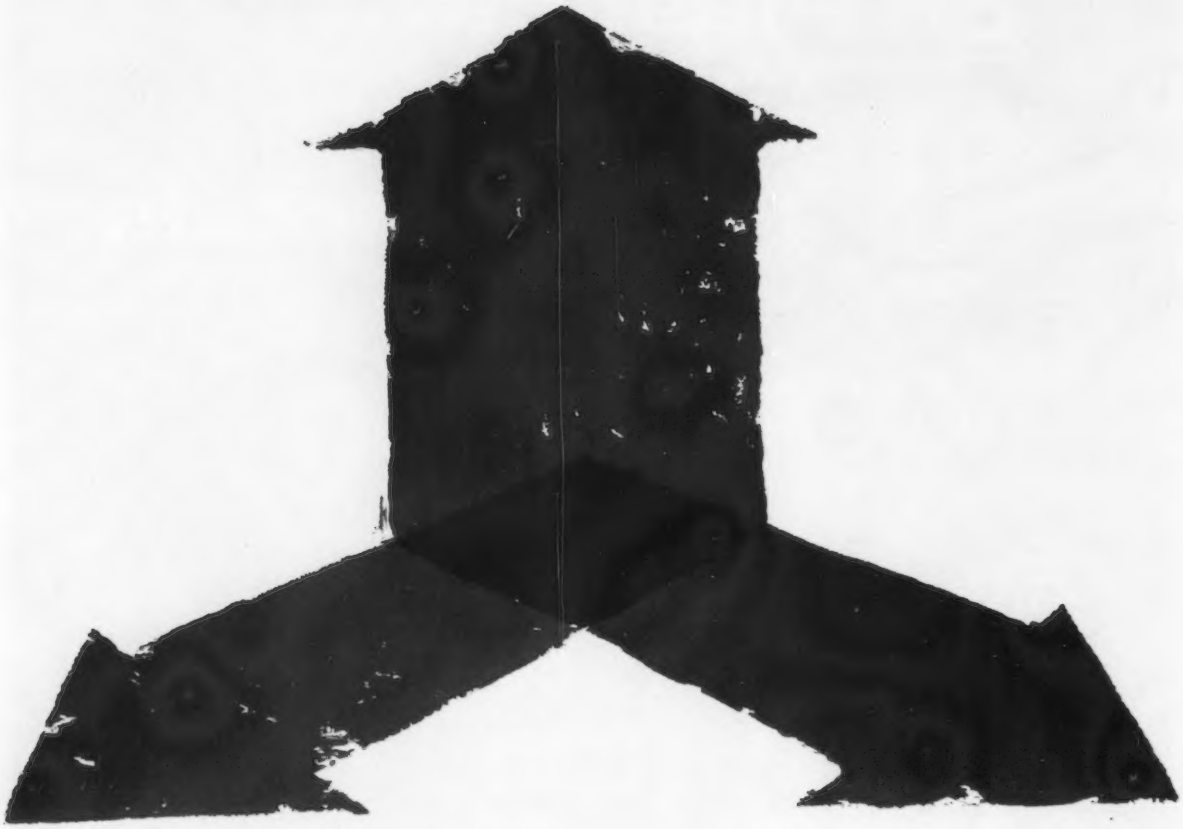

Said Hans Oersted: *"When a conductor carries current through a magnetic field at right angles to it, the resultant reaction thrusts the conductor in a direction perpendicular to both the current and the magnetic field."*

A light-weight, low fuel-consuming propulsion system is a primary requirement for interplanetary space vehicle travel. One such system now being carefully studied utilizes plasma propulsion.

This concept employs an electrical field to produce a plasma and to energize it. A magnetic field then ejects the plasma, thereby providing a reactive thrust to the vehicle.

Plasma propulsion is but one of many subjects under investigation at Lockheed Missiles and Space Division. Outstanding facilities, equipment and scientific personnel mark the organization as eminently capable of exploring many unusual aspects of space travel. This, coupled with Lockheed's favorable locations in Sunnyvale and Palo Alto on the beautiful San Francisco Peninsula, consistently attracts scientists and engineers interested in pursuing work in their special fields.

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We've got the 1950 dollar, the tax dollar, the 50¢ dollar, and a host of other kinds. How about a PROGRESS DOLLAR? How much progress are you getting per dollar?

Consumers talk of the shelter-dollar, food-dollar, clothing-dollar, take-home dollar, even lack-of-dollar. But, what part of your buck bought progress?

Industry sounds off about productivity, cost savings, product quality, and other things related to the balance sheet. Good relation. Perhaps there should be another criteria in the profit and loss statement. Simply, a measure of progress for each dollar spent. Cutting costs and cheapening the product may look good at the end of the first year. Management knows it can't go on forever that way. So, what progress was purchased that will show up in profits next year or the year after that. How much profit-dollar bought how much progress?

Government publishes much propaganda on the tax-dollar—health, welfare, defense, etc. What progress are we getting for our tax-dollar?

It's fashionable under the New Frontier to be "progressive." Does talk or lavish spending buy progress? You can legislate most anything these days, but, perhaps, progress. Oh yes, does the new minimum wage law have a measurable progress factor in it.

Are we satisfied with the amount of progress per dollar achieved over the past several years of our space program? Have the Russians done more with their PROGRESS DOLLAR in aerospace than we have in the U. S.? If your personal answers are "yes" to the first and "no" to the second, you're in complacent Utopia.

Argument after argument has been presented that we have the technology and the money to get ahead in space. Men have stated that additional money in our programs will not buy more rapid progress. Have we reached the end of our PROGRESS-DOLLAR RATIO? Maybe it's the other way—we're spending too much for too little. If this be the case, then the fault may rest with the management of our programs.

Tom MacNew

Editor

Reader's Orbit

Machinability Report . . . Write to Wright

. . . Re. the fourth item, second column, page 14 of the April 1961 issue of Aircraft & Missiles headed "USAF Machinability report . . . etc." The last sentence of the item states "Available through Manufacturing & Materials Technology Div., AMC Aeronautical Systems Center Wright-Patterson AF Base, Ohio . . ." It is a fact that Manufacturing & Materials Technology Division, LMBM, AMC Aeronautical Systems Center, has a limited number of copies available for Air Force Contractors, but only with an established "need-to-know" . . . However, the prime contractor, Curtiss-Wright, Wood-Ridge, New Jersey, (Attention: Mr. R. K. Brown, Contracts Division) has a quantity of these reports for sale. The Air Force, planning to provide for a wide distribution of these reports, made an arrangement with Curtiss-Wright to publish an additional quantity which can be obtained at $4.60 each, postpaid, Wood-Ridge.

The Manufacturing & Materials Technology Div. appreciates your article and regrets its inability to make any copies available other than to those who meet essential requirements.

Charles L. Nissley
Deputy Branch Chief
Fabrication & Components Branch
Manufacturing & Matls. Tech. Div.

Perils of Ambiguity

. . . In your May, 1961, issue (p. 16) there appeared a reference to research conducted at Battelle on the wear and friction characteristics of refractory materials. An error was made in this brief digest in quoting our conclusions. Our findings indicate that wear is less for ceramics and cermets with high thermal stress resistance and high thermal diffusivity rather than the opposite as indicated in your article.

W. A. Glaeser
Assistant Division Chief
Engineering Mechanical Div.
Battelle Memorial Institute

The culprit was traced to the following "high-octane" sentence contained in an OTS release: "Wear tends to predominate on parts with interrupted wear surfaces, such as slider bearings, in comparison with their continuous mating surfaces or ring surfaces, such as face seals, and on ceramic and cermet materials with low thermal-stress-resistance factor and low thermal diffusivity."

Readability consultants tell us they just thrive on sentences like these. We didn't break the code on this one.

Credit Where Due

. . . I hope you will pardon some constructive criticism of your "Rockets-Torpedo" tabulation (The Challenge and the Progress in ASW, April, page 45.):

Torpedo MK-39

All production and production engineering on this weapon was accomplished by Philco Corp. under contract with BuOrd. Vitro Laboratories did a splendid job initially in developing the wire guidance prior to award of the production contract.

Frank D. Peltier
Sub-Task Weapons Committee
National Security Industrial Assoc.
Anti-Submarine Warfare

Thank you for setting the record straight.

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Fight Over Parts Quality Fight

. . . I do not belittle the necessity of a QAET program (The Fight For Purchased Parts Quality, April 1961) . . . I do question as a taxpayer, the situation whereby the government pays for a qualification program but does not reap the lasting benefits of such a program . . .

I am convinced (as an engineer) that a properly prepared and used specification will guarantee the desired reliability and quality of parts . . . I know that if I completely and adequately specify requirements, I have specified my reliability. Until my prospective supplier meets these requirements, I don't buy the product.

Leonard S. Yarbrough
Electronic Engineer
ABMA, Huntsville

. . . agreed ". . . that a properly prepared and used specification will guarantee the desired reliability and quality of parts . . ." but in far too many cases there has not been sufficient emphasis on the "properly used specification" portion of this concept. A specification prepared in the best manner if not used properly, will provide little or no assurance of reliability . . .

Mr. Yarbrough says ". . . until my prospective supplier meets these requirements I don't buy the product." The question then arises—"How do I know the supplier met the requirements of the specification?"

The answer is by testing the product. This in simple terms is QAET —determining that specification requirements are met by parts . . . delivered to the government.

G. M. Ellis
Staff Engineer
Convair-Pomona

The article "The Fight For Purchased Parts Quality," By G. M. Ellis, has caused a flood of correspondence between ABMA-Huntsville, Convair-Pomona and Aircraft & Missiles. On June 7, reader Yarbrough wrote reader-author Ellis—". . . after all our correspondence, I feel we are getting to the heart of the matter of reliability . . . I understand the problems that face you. I have the same problems."

Aircraft & Missiles is gratified to have provided the platform for airing certain facets of the important reliability problem. This problem is not restricted to ABMA and Convair but is industry wide.

Look for reader Yarbrough's views on a "better way to skin the reliability cat" to appear as a feature article in a future issue.

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Qualified contractors are invited to write for further information. Write: Bendix Products Division—Aviation, South Bend 20, Indiana.

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THE Bendix CORPORATION

Projects

AEROSPACE DATA CAPSULE I

Missiles and Space Vehicles

ARCAS/ROBIN--Recent one-an-hour firing of 24 rockets has provided the greatest amount of continuous stratospheric meteorological data from 16 to 45 mi recorded to date.

BAMBI--AFSC is negotiating contracts for technological research with Convair, Space Technology Laboratories and Hughes Aircraft. Program is study of intercept of missile during boost phase.

BULLPUP--TGAM-83, trainer version of the GAM-83, will be turned over for training of F-100 and F-105 jet pilots this month. U.S.A.F. and Martin are developing GAM-83B, which will carry a nuclear warhead.

DYNA-SOAR--Goodyear will develop main landing gear skids which will look like wire brushes mounted on skis. Skid's friction will supply only braking action for landing.

DYNA-SOAR--Boeing Wichita Div. will modify a B-52 to carry vehicle on preliminary flights. Aircraft & Missiles reported plans for this in November X-15 story.

DYNA-SOAR--Boeing will spend $40-million with these subcontractors: Chance Vought for nose cap; Electro-Mechanical Research for test instrumentation subsystem; Garrett for hydrogen cooling system; Minneapolis-Honeywell for flight control electronics; Sundstrand for accessory power unit; Thiokol for solid acceleration rocket; Thompson Ramo Wooldridge for reaction control power component; Westinghouse for generator and control unit.

ECHO II--First successful inflation tests of 135 ft rigidized balloon satellite were conducted in same dirigible hangar used to test Echo I. Satellite is expected to be orbited next year as a passive communications experiment.

EXPLORER XI--Switch-over of transmission from one experiment to another at a pre-set time, after a long time delay, occurred well within NASA specs. Satellite is now transmitting data on gamma rays beyond the atmosphere.

HOUND DOG--Missiles in production are now flown away by B-52 from Edwards AFB via White Sands Range enroute to Eglin AFB. Method allows early shakedown flight for systems evaluation, and eliminates earlier transporting by C-124.

NERVA--NASA and AEC will negotiate a first phase development contract with Aerojet General and Westinghouse which will include design of the engine.

POLARIS--Experimental missile, successfully fired at Aerojet's Solid Rocket Plant, contains 1.5-million mi of glass fiber. The one-piece glass casing is 14 ft long with a 4.5 ft diam.

THOR--Air Force has ordered 22 DM-21 Thor rockets from Douglas for Transit, Discoverer, Nimbus, and other satellite projects. DM-21 model is lighter and has more powerful 165,000 lb thrust engine.

XKD2B-1/Q-12--Supersonic, expendable missile target, launched successfully recently at Pt. Mugu, is designed to provide realistic training and development testing for advanced weapons systems. XKD2B-1 simulates the speed, altitude and radar appearance of enemy aircraft and is capable of level flight at altitudes from 5000 to 70,000 ft at Mach 2.

Aircraft and ASW

ARTEMIS--Navy's long-range submarine detection project will utilize high-powered sonar transducer and high gain receivers, together with advanced data processing equipment.

Projects

AEROSPACE DATA CAPSULE I . . . continued

ASW TRAINER--"Wingless Wonder" is equipped with electronic equipment like that which was installed in P5M aircraft backfit program earlier this year. Loral Electronic supplied equipment and engineering assistance. "WW" is said to be comparable to a $2-million trainer and was constructed without cost to government.

B-52--New G and H models will shift gunner from the tail to a forward position. The tail will have a TV camera for observation.

B-52--U.S.A.F. checks have revealed weakness in wings; they blame new flight training requirements imposed on B-52. Wing structure will have to be modified. Program will take more than two years and cost $225-million, about the price of 28 new B-52's.

B-70--Crew compartment tests are being conducted in N.A.A.'s Aerospace Lab. Internal pressures of up to 21 psi will be applied to compartment.

BELL D-250 & HILLER 1100--Winners of the Army Light Observation Helicopter design competition will be a single rotor, four-place helicopter capable of carrying a 400 lb payload in addition to pilot and fuel, with a speed of 110 knots.

BOEING 727--Autopilot system to be built by Sperry. Higher degree of reliability than accustomed expected from system.

BOEING VERTOL 107--Sweden has ordered the 107 for the Navy and Air Force. Plans call for eventual use by all three services.

CANADAIR 44--Function and reliability testing of swing-tail air freighter complete. Deliveries will be made soon to U.S. cargo airlines.

CONVAIR 540--New trend in Aerospace Ground Equipment (AGE) is to take it with you. 540's are being equipped to be completely independent of ground support. "Stinger" auxiliary power system provides pneumatic and electrical power for engine warmup and starting, ground air conditioning or heating in cabin, ground checkout of electrical systems and other support needs. Tail cone ("stinger" area) is depressurized and an AiResearch gas turbine installed along with ducting and other equipment.

CONVAIR 990--Flight up to Mach .97 at altitude of 22,500 to prove design changes after flutter problems in outboard pods. Normal operation speed claimed as Mach .91.

DASH--Drone Antisubmarine Helicopter equipped destroyer will have long-range striking capability. Recent tests at sea have proved feasibility of the DASH weapon system concept.

GULFSTREAM--Two Grumman Gulfstreams being modified as aerial laboratories for the FAA for performance testing of various airways navigational systems and airborne equipment.

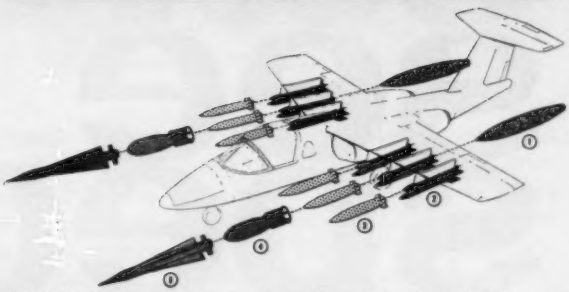
H-43B HUSKIE--U.S.A.F. claimed a new altitude record of 25,814 ft for helicopters carrying 2204 lb, breaking previous Russian record.

SATIN--(SAGE Air Traffic Integration) Experimental air traffic control system being designed by Mitre Corp for FAA.

SIKORSKY HSS-2--First carrier suitability trials successfully completed. Navy pilots flew HSS-2 for two speed records; 174.9 mph over a 62 mi course and 192.9 mph over a 3-kilometer straight-away.

V/STOL--Studies at GE of a lift-fan powered Vertical/Short Take-off and Land aircraft place lift-fan in each wing and two J85 jet engines in the fuselage. GE estimates first flight test could be made in 1963.

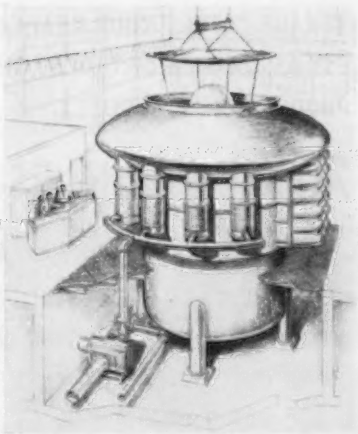
AEROBEE-HI nose cone operates similar to the Venus-fly trap. Designed to catch anything from floating particles to high-speed micrometeorites, leaves opened at 40 mi height. Rocket carried Aerojet equipment to 105 mi where leaves retracted and nose cone sealed itself. Space dust snaring equipment consists of boxes containing electron microscope screens and plastic material, 3 x 2 in., in triple layers on leaves. AF Cambridge Research Lab is examining payload.



SAAB 105 armament alternatives: 1. Two 12.7 mm guns in pods (200 rounds/gun) 2. Twelve 13.5 cm rockets 3. Six 120 kg bombs 4. Two 250 kg bombs 5. Two air-to-surface missiles.

SATURN S-IV airlift on top of C-133 transport is under study by NASA. Douglas proposal calls for attaching lightweight fairings to front and rear of S-IV to reduce drag. Windtunnel testing of the piggyback technique has indicated its practicability.

POLARIS Mark 1 inertial guidance system is smallest in use in U. S. ballistic missiles. GE's Ordnance Dept. has received more than $120-million over a four-year period for system.



OAO (Orbiting Astronomical Observatory) prototype will be tested in Grumman Space Simulation System which Chicago Bridge & Iron expects to complete by Dec. System is capable of simulating 150 mi high environment.

POLARIS heat-resistant insulator is X-rayed for flaws. Insulator protects motor case during last few seconds of firing. B. F. Goodrich is also making Minuteman insulators.

TITAN I silo launch at Vandenburg shown in artist's concept. Acoustic vibrations were damped by attaching three-ft thick fiberglass acoustic liner to steel walls of launch duct and lining twin exhaust ducts.

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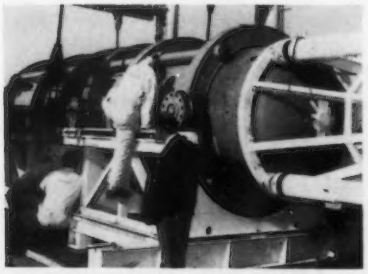
Technical Advances

AEROSPACE DATA CAPSULE 2

R & D BRIEFS

ROCKET BELT flight successful in Bell Aerosystems' experiment for Army Transportation Research Command. Man-rocket has twin-jet hydrogen peroxide propulsion system mounted on fiberglas corset custom-fitted to operator.

Launching track, according to French trade paper, "Le Journal Du XX Century" and "L'Auto Journal," is being used to launch Russian rockets. Ramp 15 mi or more in length supposedly swoops down one mountain slope and up another. If this is true, Russians have solved problem of side-gravity encountered in early U. S. experiments.



SEGMENTED SOLID ROCKET fired by Aerojet-General developed 160,000 lb thrust. 65 in. diam motor segments are shown in cylindrical hold-down harness. 100 in. diam full-scale motor will be tested later this year.

Laminar flow control system (Northrop) will be tested on a clean wing. The two engines powering the WB-66D weather reconnaissance aircraft used as a test vehicle will be moved Caravelle fashion to the aft fuselage.

Venus radar bounce experiments by JPL shows astronomical unit AU to be 92,956,000 plus or minus 1000 mi reducing previous margin of error by 50,000 mi.

Magnetic field fluctuation being studied at Sylvania's Applied Research Lab, may provide insight into causes of violent electrical storms.

FLEX WING successfully flown in 100 hp prototype. Flying and application engineering being done by Ryan for Army Transportation Research Command. First stage booster recovery using flex wing being studied for NASA.

Sea water conversion plant will be built by Rocketdyne near Oxnard, Cal. Pilot plant will produce from 15,000 to 20,000 gal of fresh water daily.

Prolonged space flights' effect on man's brain will be studied at UCLA Space Biology Lab under A.F. grant.

Sun-powered laser would permit use of direct sunlight to power space communications system. American Optical has started development of laser and expects that it would provide 10 times the beam intensity of light on earth than could be provided by direct reflection of the sun.

Underground waveguide communications could be only reliable means in the event of nuclear attack. General Telephone & Electronics' concept would make use of natural waveguides in the various layers of wet and dry rock below the earth's soil crust.

AIR TRAILER concept for carrying large missile stages designed by Ling-Temco Electronics. Model has a 160 ft length and 210 ft wingspan which could carry loads with 24 ft diam, 90 ft long, 50 T weight.

Controllable thrust solid propellant rocket motor has been successfully tested by Amcel Propulsion. Under company sponsored development, experimental motor demonstrated 4 to 1 throttling ratio. Performance thus far has been maintained at 93 per cent theoretical value.

Aviation electrical system capable of operating at temp from —65° F to 600° F has been designed by General Electric. The Hotelec system is the forerunner of those which will be used in ultrasonic aircraft or space vehicles.

Tech Advances cont'd next page

Technical Advances

AEROSPACE DATA CAPSULE 2 . . . continued

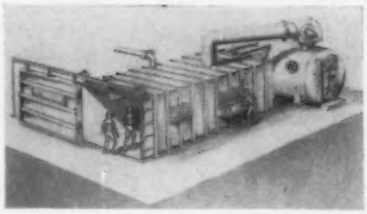
EQUIPMENT

INFLATABLE SPACE STATION could be boosted into orbit in a package. 30 ft expandable station could be inflated into shape to permit one or more persons to live and work inside the tube for an extended period. Goodyear Aircraft is building a similar 24 ft diam station for NASA tests.

Telemetry system allows reduction in transmitter power required to send accurate radiation measurement signals from space. 12 lb package includes seven lb of batteries. Space Electronics Corp.'s system will fly in Blue Scout Junior research rocket later this year.

SOLAR GENERATOR for space vehicles, developed by United Aircraft's Hamilton Standard Div., is said to supply ten times as many watts per lb of generator weight as any existing system. Unit has no moving parts. Small aluminum reflectors and thermocouples collect the sun's energy and convert it directly into electricity.

Daylight photography of missiles, satellites and planets possible with giant Facet-Eye Camera System which was basically conceived for the purpose of tracking missiles, satellites and other space-bound objects at extreme distances and in any kind of light.



SPACE-FLIGHT test chamber, shown in artist's conception, will simulate environmental conditions for astronaut training and equipment testing. Designed and built by Vacudyne for the Bio-Astronautics section of Boeing.

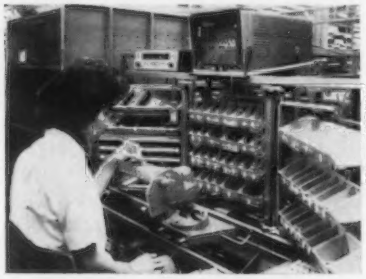
Liquid oxygen converter, designed for space flight, is capable of operation under zero gravity conditions. Report (PB 171 554) available from OTS, U. S. Dept. of Commerce, Washington 25, D. C. $1.75.

HELICOPTER pilot self-trainer consists of a fully operational one-man helicopter mounted on a mobile GEM. Del Mar Engineering is testing an automatic flight instrumentation package that converts the basic Whirlymite to a drone.

Undersea radiation measuring device, called DUNC, Deep Under-Water Nuclear Counting, is so sensitive that it can detect one atom of radium in a billion billion molecules of water.

Stepped air bearings developed by Boeing will be licensed to interested companies for possible use in machine tool and other high speed rotating devices.

PRODUCTION



PRODUCTION SPEEDUP with audio-visual aids has undergone tests at General Dynamics and shown 40 per cent gain in production time over multiple-station line-flow operation. Operator observes slides on eye-level screen while listening through ear phones to detailed description of assembly steps.

Hydraulic jig setters in use at Lockheed reduce fixture setting time by 80 per cent in some cases. Special Products Sales unit of California Div. is marketing device.

Liquid lathe jetting fluid under thousand of pounds pressure found safe in removing solid propellant materials from engine casing. Machine developed and manufactured by Abrasi-Jet Machine Tool Corp. from NAVAN Div. of N.A.A.

Procurement

AEROSPACE DATA CAPSULE 3

Small Business' Share

Army Ordnance Missile Command will send a team of 10 procurement experts out for on-site program reviews in an effort to channel more dollars to small business. AOMC hopes to obligate 95 per cent of its expected year-end parts and equipment for missiles awards by mid-year. In addition to placing $15-million with small business in the last half of 1961, AOMC is aiming at placing $60-million with small business in FY 62.

President Kennedy hopes for a ten per cent, or $344-million, increase for FY 62 of defense contract dollars awarded to small business firms.

Air Force Procurement

The Procurement Policy Development Branch wants to know what USAF procurement methods should be five or ten years from now. Its basic objective is to modernize USAF procurement regardless of changes that might have to be made in procurement concepts, statutory authority, organizational structure or dept. rules and regulations. Private comments are solicited. Send your ideas to AFMPP-PR-4, Hq USAF, Washington 25.

Business Moves

FMC (Food Machinery and Chemical) Corp. will build a hydrogen peroxide plant in West Virginia.

Astro-Science Corp. has bought American Electronics' El Monte, Cal., Ground Support Div. New unit will be known as Astro-Systems, Inc.

B. F. Goodrich Aviation Products has established complete engineering and production facilities for filament-wound structures.

British Aircraft Corp. (U.S.A.) formed to promote sales of aircraft and guided weapons in U. S. Headquarters will be in Arlington, Va. BAC was formed last year by Bristol Aeroplane, English Electric and Vickers.

General Precision, Inc., has established an Air Traffic Control Dept. at Tarrytown, N. Y., to manage air traffic control programs of its four divisions.

Contracts

General Electric — $13-million for Atlas base equipment; $6-million for OAO control system; $4.5-million for Polaris guidance; $3.8-million for 20 mm Vulcan guns for F-104G; and $36-million for Navy's AN/SPS-30 shipboard height finding radar.

Sperry Gyroscope—$33.4-million for Terrier guidance and $11.5-million to Sperry Utah during recent months for repair parts for Sergeant.

Bendix Corp. — $12-million to equip NATO aircraft with advanced navigation systems; $1.79-million for Army airborne missile measuring equipment; and $670,000 from Navy to initiate system engineering on Advent shipboard terminal.

Lycoming Div., Avco Corp.— $18-million in new turbine contracts for Iroquois, Chinook and Mohawk engines.

Bath Iron Works Corp.—$58-million for three missile frigates.

Huyck Systems Corp.—$750,-000 from Lockheed for Doppler/Air Mass Navigational Computer for P3V-1.

General Telephone & Electronics—$1.2-million for ground stations brings Sylvania Advent awards to $3.6-million.

Philco Corp. — $35.8-million from AF for continued development of command and control subsystems.

Vertol Div. Boeing—$291,000 for further development of Vertol 76 tilt wing VTOL aircraft.

Western Electric Co. — $2.28-million for components for Nike Hercules system; $7.05-million for Nike Zeus system; and $19-million for Universal Integrated Communications System (UNICOM).

Raytheon Co. — $2,025,700 from Army for Hawk ground equipment.

Garrett Corp.—$1.3-million for engine starters for AF Hound Dog and $5.2-million from Navy for aircraft gas turbine compressors.

Collins Radio Co.—$3,226,000 for data transmission equipment for SAC world-wide system, $1.5-million from Navy for F4H-1, A3J and A2F CNI systems; $640,679 for ground equipment; and $3.3-million for airborne distance measuring equipment (DME).

RCA — $3.25 - million from NASA for Project Relay satellite.

Fairchild Stratos Corp. — $7,-875,000 for AN/USD-5 (XE-2) version of SD-5 drone.

Hughes Aircraft Co.—$9.37-million raises dollar volume in Polaris program to approximately $30-million, mostly for missile guidance.

Texas Instruments, Inc. — $1-million from Navy for AN/APS-88 radar for carrier-based planes.

Guidance Technology Inc.— $1.9-million from Navy for ground control bomb directing system for light jet attack aircraft.

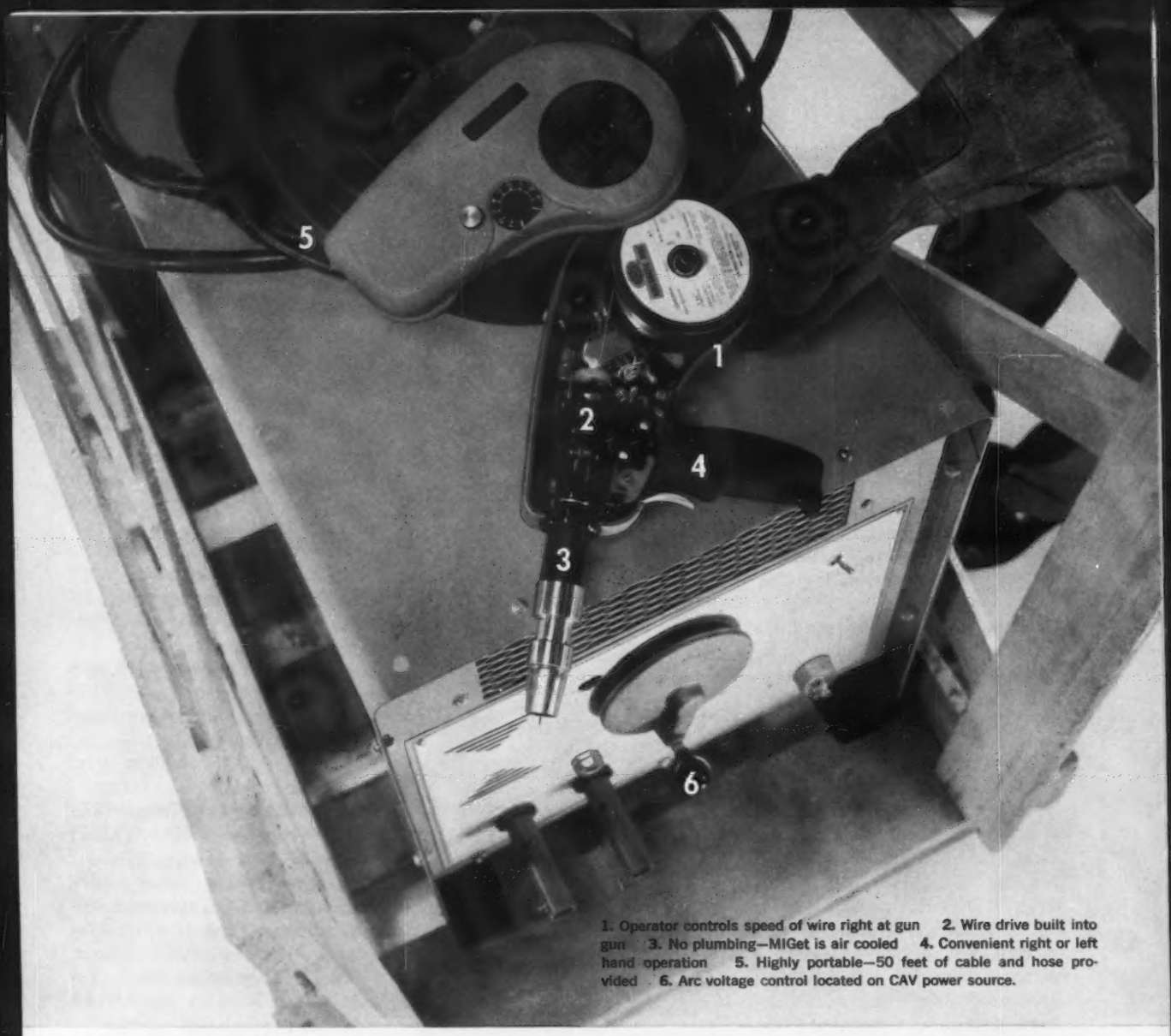
Minneapolis - Honeywell — $7-million from Convair for Atlas F ground equipment.

Aerojet-General—$4.8 million for work on Saturn static test facility at Marshall Center.

Douglas Aircraft — $11.6-million for Genie replacement motors and other equipment.

Kollsman Instrument — $2.8-million for celestial guidance ground equipment.

North American Aviation— $21-million for Ship's Inertial Navigation Systems for Polaris subs.



1. Operator controls speed of wire right at gun 2. Wire drive built into gun 3. No plumbing—MIGet is air cooled 4. Convenient right or left hand operation 5. Highly portable—50 feet of cable and hose provided 6. Arc voltage control located on CAV power source.

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Airco now gives you the simplest, lowest price gas-shielded metal-arc welding package in the industry—

(1) Hi-speed highly portable MIGet welding gun, with handy knob to adjust wire feed speed; model AH20-E.

(2) New Aircomatic MIGet CAV power source, with control to adjust arc voltage.

The new MIGet UNIT PACKAGE enables you to make numerous short-length welds . . . at a remarkably low cost. You can work up to 50 feet from the power source, on anything from radar antennas to crawl-in tunnels.

You can weld mild steel with Dip Transfer using CO_2 or AG25; aluminum with Spray Transfer or Dip Transfer using argon; stainless steel with Dip Transfer using AG1.

The MIGet gun connects directly to the power source. It weighs only 2¾ pounds. Handles .030" and 3/64" aluminum wires, and .030", .035" and .045" hard wires. It is rated at 200 amperes 100% duty cycle.

The power source, in which the "welding current takes care of itself," is a single phase, DC rectifier, CAV type, rated at 200 amperes 60% duty cycle. Reactance for Dip Transfer is built in.

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Market Planning

AEROSPACE DATA CAPSULE 4

New Markets For Safety Devices

The impact of 12 fatal aircraft accidents in 1960 will open the door for drastic changes in equipment and operations among airlines. About 160 new projects were initiated in this area during 1960. New ideas for aviation safety will soon find an even more-receptive market.

Important gap areas are pinpointed in the recent 11th Annual Survey of the Cornell-Guggenheim Aviation Safety Center. They are:

(1) **Air Traffic Control:** Increased numbers and speeds of aircraft have already outstripped provision for advanced equipment.

(2) **Occupant Protection:** Airlines have a responsibility to increase protection despite public willingness to take risks.

(3) **Airport Limitations:** About 92 per cent of airline airports have inadequate fire protection; 70 per cent have no approach lights; 58 per cent have no control towers.

(4) **Approach & Landing:** Forty per cent of all fatal accidents occur just short of the runway threshold.

(5) **Monitoring Systems:** Electronic devices are needed to show ground personnel and pilot when an aircraft is deviating from flight plan beyond safe limits.

(6) **Collision Avoidance:** A warning device of only 10-mi-range would have eliminated 90 per cent of all accidents in 1960.

(7) **Fire Crash Protection:** No transport is equipped with life-saving systems for crash landing fires.

(8) **Component Reliability:** Engineers point out that quality control, and reliability planning could stop many aircraft and missile failures.

Ten Year Forecast For Inner Space Spending

Navy has charted a ten-year course for exploring the ocean depths that will result in $900 million of spending. Called TENOC 61 (Ten Year Program in Oceanography) the program calls for exploration of nine major fields in the ocean-deep, sometimes called "inner space."

(1) **Oceanographic Surveys $128 million.** Objective is to accurately map the ocean floor. A ten-fold increase in basic data collection will be sought.

(2) **Forecasting $18 million.** Objective is to have by 1965 a system for predicting ocean currents, sea ice, etc. One phase of the program is called ASWEPS Antisubmarine Warfare Environment Prediction System.

(3) **Information Dissemination $12 million.**

(4) **Military Oceanography $245 million.** Object is to get acoustical, magnetic, and gravity information for better underwater detection systems.

(5) **Ships $229 million.** Navy now has 13 survey ships, 20 miscellaneous craft, and uses 30 civilian ships part time. Thirty-five special oceanographic ships are planned.

(6) **Instruments $46 million.** Specific requirements are improved sensors, cable and connectors, monitors and recorders, and telemetry.

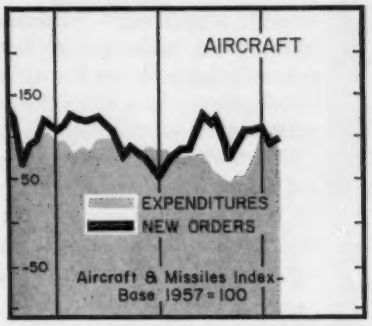
(7) **Facilities $18 million.**

(8) **Basic Research $210 million.** Most of this money will go to universities.

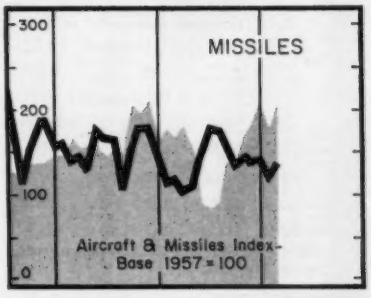
(9) **Recruitment and Training** (no funds specified).

Market Planning—cont'd next page

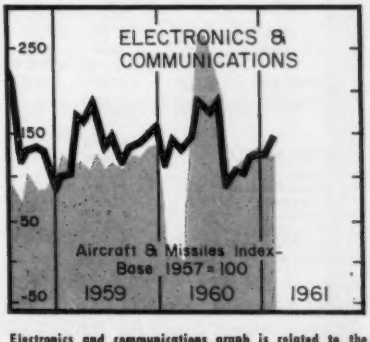
DEFENSE EXPENDITURES AND NEW ORDERS
3 Months' Moving Average Index



Aircraft includes air-frames, engines armament, electronics, and other government furnished equipment. Also included: special tools, test equipment, and ground handling equipment.



Missiles graph includes complete missile systems—armament, launching, guidance, control, boosters, sustainers, propellants, special tools, and ground handling equipment.



Electronics and communications graph is related to the following equipment: radar, electromagnetic equipment, computers, radiation airs, countermeasure, radiac and infrared, meterological equipment, sonar, transmission or reception units, noise and interference detection devices, test equipment, spares, and related component equipment.

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Who's Buying What In 1962?

After a great deal of revising and re-revising the aero-space spending patterns for fiscal 1962 are firming. The following table gives a detailed procurement breakout for the military and civilian agencies. A separate table gives major category figures for Air Force Research & Development, Test & Evaluation; this latter request has not yet been approved by the Congress.

Major changes between the Eisenhower and Kennedy budgets are: (1) Increased spending for NASA, man-in-space gets a great deal of the new funds; (2) Increased spending for AF big bombers; (3) Termination of the nuclear aircraft.

Developments to watch in the aerospace market are: The determination of the new administration to meet the Russians' challenge of placing a man on the Moon in this decade; and the appointment of a new Chief-of-Staff to the Air Force.

What will these two events do to the market? The first could result in an increase of $20 to $40 billion worth of expenditures in the next ten years. If this program goes to fruition it will throw just about every forecast for space spending out of balance. The second, the appointment of General LeMay as AF Chief of Staff, could give new vigor and longevity to the aircraft market. LeMay is an avowed Big-Bomber-Man. He has never been eager about big spending programs for the silo-housed ballistic missiles. He has been reported as stating that he places missiles last on his list of things that Air Force needs.

AIR FORCE

$3.5 billion aircraft
$2.8 billion missiles

AIRCRAFT		Amount (Millions)
Boeing	KC-135	$230.0
Boeing, Convair	B-52, B-58	$525.0
Boeing	C-135	$ 21.2 (fan version)
Lockheed	T-40	$ 19.1
Lockheed	RC-130	$ 7.4
Northrop	T-38	$129.0
NAA	B-70	$218.0
NAA	T-39	$ 50.3
Republic	F-105 D	$370.0
Republic	RF-105	$ 27.5
Modification		$672.0
(B-52, $230 million; F-105, $50 million; B-58, $18.5 million)		
AGE (common in service)		$ 87.7
Spares		$875
Component improvement		$ 46
Industrial Facilities		$ 23

MISSILE		
Convair Atlas		$202 ($3.8 billion thru '62)
Martin Titan		$1,100 ($4.2 billion thru '64)
Martin Bullpup		$ 26.7
Boeing Minuteman		$924 ($12.1 billion thru 62)
NAA HoundDog		$ 90.4
NAA HoundDog . . air borne alert		$ 41.0

AIRCRAFT/MISSILE	Amount (Millions)
Q-2C drone	$ 10.9
Undisclosed Projects	$122
ICBM Support	$180
Modifications	$ 25
In-Service Support	$ 22.8
Component Improvement	$ 4.0
Industrial Facilities	$ 14.0

Note: AF plans to use $1.12 billion of its procurement funds for R&D, T&E as follows: (1) Atlas $73.5 million, (2) Minuteman $377 million, (3) Titan $356.4 million, (4) B-70 $218 million, (5) C-141 $98 million.

NAVY

$1.6 billion (aircraft)
$606 million (missiles)
$27 million (missiles Marines)

AIRCRAFT		No. Planes
Grumman	S2F-3	48
Grumman	W2F-1	12
Grumman	A2F-1	24
Chance Vought	F8U-2N	72
Kaman	HU2K-1	48
Sikorsky	HUS-1	70
Sikorsky	HSS-2	42
Lockheed	P3V-1	36
Lockheed	C-140	?
McDonnell	F4H-1	88
Douglas	A4D-2N	?
Douglas	A4D-5	180
NAA	A3J	?
NAA	T39	10
Boeing-Vertol	HRB	14

	Amount (Millions)
Test Engines, etc.	$ 15.8
Spares	$421.0
Industrial Facilities	$ 5.0
Modernization	$ 50.0
DASH	$ 8.7

MISSILES		Amount (Millions)
Raytheon	Sparrow III	$ 37.8
Philco	Sidewinder IC	$ 25.2
Convair	Terrier	?
Convair	Tartar	$ 45.3
Bendix	Talos	$ 36.8
Martin	Bullpup	$ 26.2
Chance Vought	Regulus 1	?
Goodyear	Subroc ($100 million ultimate expenditure)	$ 6.7
Lockheed	Polaris	$300+
Astronautics		$ 4.8
Industrial Facilities		$ 1.0

ARMY

$211 million aircraft
$551 million missiles

AIRCRAFT		No. Planes	Amount (Millions)
Boeing-Vertol	Chinook	24	$ 35.4
Bell	Iriquois	242	$ 67.6
Beech	Seminole	14	$ 1.8
de Havilland	Caribou	48	$ 30.2
Grumman	Mohawk	48	$ 42.8
Spares			$ 33.2

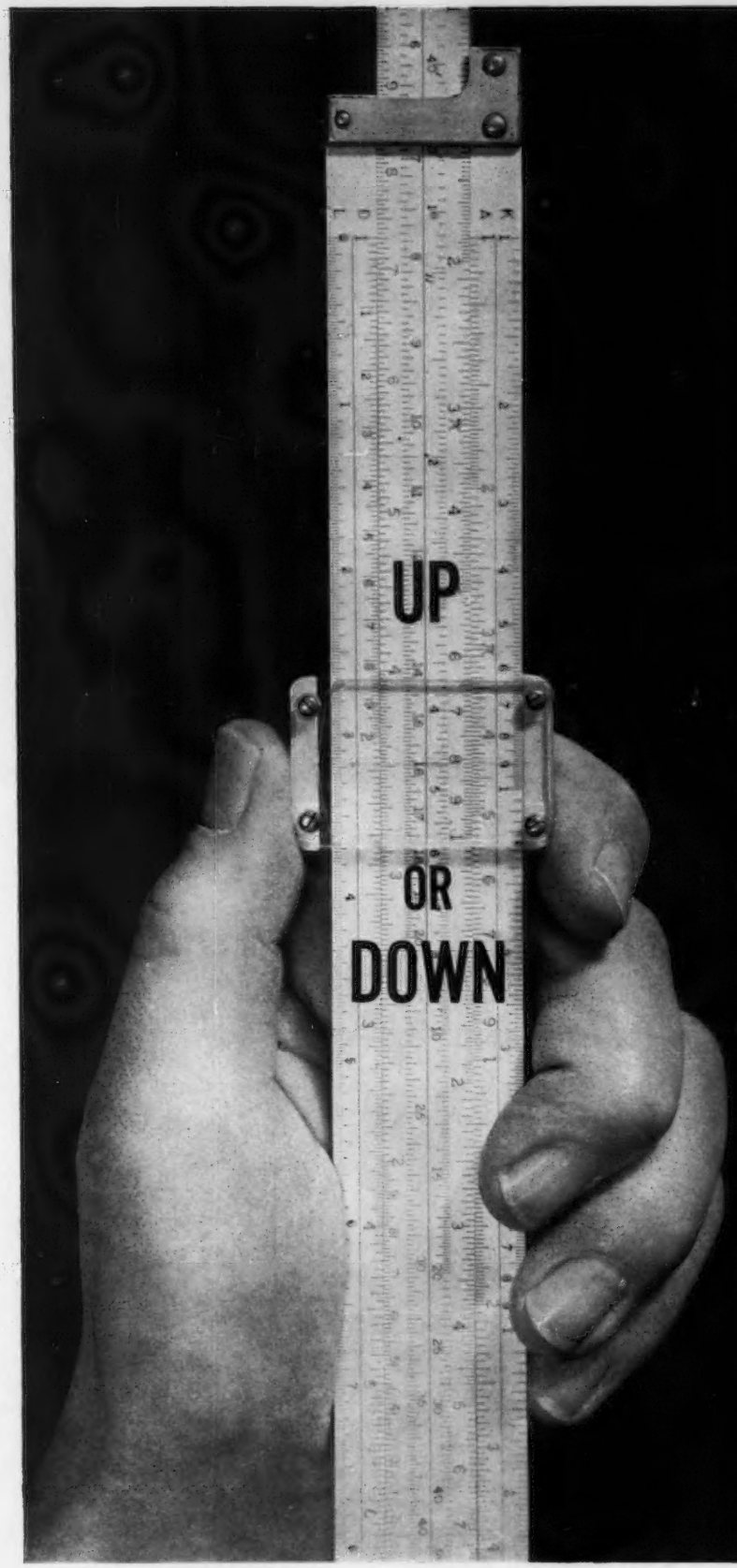
MISSILES (ARMY cont'd)		Amount (Missiles)
Raytheon	Hawk	$127.7
Martin	Pershing	?
Sperry	Sergeant	$ 93.0
Convair	Redeye	?
Emerson Electric	Honest John	$ 16.7
Western Electric	Nike Hercules (AGE)	$ 78.0
Nord	Entac	$ 9.8

NASA FISCAL '62 R&D
Kennedy Request (May)

Support of NASA plant	$ 89,110,000
Research grants and contracts	7,600,000
Life sciences	20,620,000
Sounding rockets	9,000,000
Scientific satellites	72,700,000
Lunar and planetary exploration	159,899,000
Meteorological satellites	50,200,000
Communication satellites	94,600,000
Mercury	74,245,000
Apollo	160,000,000
Launch vehicle technology	27,000,000
Launch operations development	1,500,000
Spacecraft technology	10,360,000
Solid propulsion	3,100,000
Liquid propulsion	93,020,000
Electric propulsion	6,800,000
Nuclear systems technology	36,000,000
Space power technology	5,500,000
Scout	3,675,000
Delta	2,900,000
Centaur	56,400,000
Saturn	224,160,000
Tracking and data acquisition	38,650,000
Nova	48,500,000
Total	$1,295,539,000

AIR FORCE R&D, T&E REQUEST
Fiscal 1962
$1.93 billion

	Million
Strategic Systems	$ 406.5
Air Defense Systems	$ 217.4
Tactical Systems	$ 4.2
Support & Control Systems	$ 88.6
Operational Support	$ 39.1
Advanced Development:	
Systems	$ 267.1
Subsystems & Comp.	$ 10.0
Test Instruments	$ 16.7
Dev. Support	$ 112.9
Applied Research	$ 266.9
Basic Research	$ 52.5
Command Operations	$ 450.0
Total	$1,931.9



It's either one or the other. You are a senior engineer experienced in Design, Test, Research or Product Development and you are *going up* with a company that offers opportunity to express your abilities in the form of original ideas.

Or you are *going down*, losing ground with a company that is failing to progress with technological advancements, or restricts you to routine assignments.

If you are caught up in the latter situation and would like to join a truly dynamic company — a company capable of setting the pace in a fast-moving industry — get the facts about Boeing-Wichita today:

Assignments available in STRUCTURAL DESIGN AND DYNAMICS, STRESS ANALYSIS, AERODYNAMICS, AUTOMATIC CONTROLS, ELECTRICAL AND ELECTRONICS, ACOUSTICS, AIR CONDITIONING, SYSTEMS DESIGN AND FLIGHT TEST. Positions in these areas offer excellent professional growth opportunities for men who are *going up*.

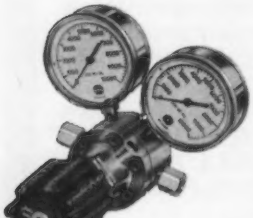
If you are qualified by education and experience and would like to know more about specific assignments and about living conditions in Wichita, write in confidence to Mr. Melvin Vobach, Dept. 087, Boeing Airplane Company, Wichita 1, Kansas. Equal job opportunities to all qualified applicants.

BOEING / WICHITA

VICTOR "CLEAN" REGULATORS

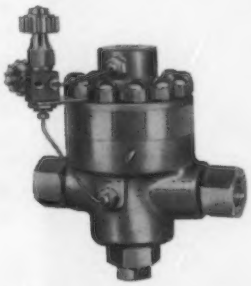
Control gases safely and accurately to 10,000 psig.

Victor high pressure gas regulators are cleaned, assembled, tested and packaged under carefully controlled conditions to insure maximum product reliability. Cleaning is performed to Victor standard or to customer specifications in a room approved by industry and military agencies. Regulators shown here are typical of the available models covering a range of pressures to 10,000 psig. and capacities of 80,000 scfm. at —67° F. to +250° F. Write for Regulator Inquiry Form 361B and regulator bulletins.



GD700 SERIES
GAS-O-DOME REGULATORS

Bronze or stainless steel
Pilot operated—low torque
Inlet to 10,000 psig.
Outlet to 10,000 psig.
Flows to 250 scfm.
Panel Mounting



GD40, GD90, GD100, GD200 SERIES
GAS-O-DOME REGULATORS

Bronze or stainless steel
Remote or integral controlled
Inlet to 6,000 psig.
Outlet to 6,000 psig.
Flows to 80,000 scfm.
Panel mounting if desired.

LR SERIES LOADER REGULATORS
BPR SERIES BACK PRESSURE
REGULATORS

Bronze or stainless steel
Inlet to 10,000 psig.
Outlet to 10,000 psig.
Flows to 10 scfm.
Low operating torque:
40 inch lbs. at 7,000 psig.
60 inch lbs. at 10,000 psig.
Panel mounting.

GD60 AND GD80 SERIES
GAS-O-DOME REGULATORS

Bronze or stainless steel
Remote or integral controlled
Inlet to 10,000 psig.
Outlet to 10,000 psig.
Flows to 2,000 scfm.
Panel mounting if desired.

VICTOR for regulators

VICTOR EQUIPMENT COMPANY

844 Folsom St., San Francisco 7 • 3821 Santa Fe Avenue, Los Angeles 58
1145 E. 76th St., Chicago 19
J. C. Menzies & Co., Wholly-Owned Subsidiary

Mfrs. of high pressure and large volume gas regulators; welding & cutting equipment; hardfacing rods; blasting nozzles; cobalt & tungsten castings; straight-line and shape cutting machines; roller and idler rebuilding machines.

Management

AEROSPACE DATA CAPSULE 5

CORPORATE CO-OP

Thiokol Chemical Corp. and French Société d'Etude de la Propulsion par Reaction have completed sales agency arrangements in their respective territories in the field of solid rocket engines. Agreement also calls for exchange of related technical information.

Grumman Aircraft Engineering Corp. and Brequet in France have agreed to an exchange of technical information, availability of manufacturing facilities, and the sales promotion of products.

Avro Aircraft Ltd. and the Ingersoll Kalamazoo Div of Borgwarner Corp. will cooperate in future Ground Effect Machine programs.

Motorola, Inc., and General Precision, Inc., have formed a team to present a new approach to air traffic control communications. System provides tie-in of automatic communications with the new Data Processing Central air traffic control system undergoing FAA evaluation and initial implementation.

Mutual support agreement in engineering and marketing of automated control systems and processes announced by Allis-Chalmers, Consolidated Systems Corp., and IBM. A typical integrated system will utilize A-C's basic instrument equipment, Consolidated Systems' special instrumentation and IBM's data processing equipment.

DIRECTORATE

Five internationally-famed scientists will assist the Douglas Aircraft Co. in planning the basic and applied research programs vital to the development of its space, missiles and aircraft systems of the future. The scientists will serve as consultants in selecting long-term research goals and the type of facilities, equipment and personnel needed to achieve these targets.

TREE SHAKERS

$119-million harvest has resulted from first full quarter's operation of Project "Money Tree," the Air Force Logistics Command's plan to get the most for their money. Command officials indicated that significant savings were reported in almost every management area.

SPACE INSURANCE

NASA is seeking authority to insure space contractors against catastrophe during work on super rocket boosters. They asked Congress for authority to insure firms up to $500-million in high risk work. The military and AEC already have this insurance authority.

MANAGEMENT QUOTES

Roswell L. Gilpatric, Dep. Sec. Defense at AIA conference; ". . . in 1951, over 87 per cent of our procurement was through fixed-price contracts. . . . Now I find that cost-reimbursement contracts account for almost 43 per cent of our procurement. . . . The basic reason for this trend, of course, is the changing character of the Defense program."

Dr. L. S. Sheingold, Dir. Sylvania's Applied Research Lab and U.S.A.F. Chief Scientist-Designate; ". . . scientific knowledge necessary for making the right decisions is somewhat less than adequate at the top decision-making levels." He pointed out the present industrial movement toward management training.

Robert S. Stevenson, Pres. Allis-Chalmers; "If Congress would come through with a piece of really positive depreciation allowance legislation, the machinery industry should not only improve along with general business, but would become a major force in the economy's advance."

Joseph V. Charyk, A.F. Under Sec., criticized what he termed "technical irresponsibility" on the part of some suppliers of defense material and their attempts to obtain contracts through "highly Speculative" concepts. "Sometimes accomplishment seems to be measured by the size of the contracts, rather than by the efficiency with which the job is executed."

Dr. Raymond J. Nelson, Dir. Case Institute of Technology's Computing Center, speaking of the computer's present uses, "The conquering of space, the dealing with complicated business management problems and the understanding of intelligence behavior in animals and human beings would hardly be possible without high speed computing equipment."

Welcome W. Bender, Dir. Martin's Research Institute for Advanced Study; "Although all segments of the U. S. economy benefit from the continuous flow of ideas from pure science, no one seems actively to claim support for the care and nourishment of the stepchild. Rarely do economic benefits accrue to the scientists and the institution. . . ."

Arthur A. Collins, Pres., Collins Radio Co., "We have more new products under development than at any time in the Company's history. Management is confident that the ultimate results of this program will justify the substantial amounts that have been and will be invested."

Eugene G. Hart, Pres. International Research and Development Corp.; "Technology has eliminated the need for much unskilled labor. Much of this labor has to be trained if it is to be employable. The question confronting industry is whether industry or government will do it. It will cost industry less to do it itself."

Navigation by sure eye and steady hand

Ferdinand Magellan successfully steered his ships around the world with the aid of an "astronomical ring" . . . one of the navigational wonders of his age. Hung from the steady hand of a sure-eyed seaman, readings were taken by sighting through the rings. Set for the month and day of the week, this ingenious device employed the sun's declination to first determine latitude, then the hour and finally the meridional point of the ship's position.

Today, the "sure eye and steady hand" of Arma's inertial guidance system solves the intricate problems posed by navigating in space . . . keeps space vehicles on course by sensing the most minute changes from programmed speed and direction. And, despite its precise capabilities, the sensing gyro of the guidance system is small enough to be completely encompassed within Magellan's unique brass rings.

Arma, developer of the all inertial Atlas guidance system, airborne fire-control systems, weapons systems for all Navy submarines, and pioneer in space research programs, provides industry and the defense establishment with products and systems of top reliability and value. ARMA, Garden City, New York, a division of American Bosch Arma Corporation . . . the future is our business.

AMERICAN BOSCH ARMA CORPORATION

THE COVER STORY

COOPER and REINSCH
. . one question is basic . .

Speedy travel was once a luxury for the rich, or a thrill for the adventurous. Today it is a symbol of, if not the force behind, an advanced economic and political community.

We are on the threshold of a new dimension in manned flight—Mach 3. Military and civilian management alike has an eye on the potential of supersonic flight. Both segments of the aerospace industry are gearing to the challenge of a new set of problems and technologies.

B-70 has already set the course for the solution of some problems. Many problems are in an uncharted domain.

This month's cover personalities are North American materials men, Wayne Reinsch and Frank Cooper. They lead off a Special Report on Man and Machine at Mach 3+ with a penetrating anlysis of what B-70 has already given to materials technology.

Materials For Mach 3+

- ***Which materials and processes can management count on for 1965? 14.5 million engineering man hours in B-70 show the way.***
- ***Nowhere have we asked so much of every pound of structure as in B-70.***
- ***Poor materials selection drives weight and costs up, keeps performance down.***
- ***Non-metallics hold the key to successful seals, insulation, coatings and fluids.***

Non-Metallics by Frank M. Cooper,
Materials Research Specialist, NAA

Metallics by Wayne A. Reinsch,
Materials and Process Engineer, NAA

Manned flight at Mach 3 is staring us in the face. It will tax aerospace technology to the limit. We dare not turn our backs to the challenge.

Once the decision to meet the challenge has been made, one question becomes basic. "From what materials will we make a Mach 3 airplane?" Designers on the B-70 have some of the answers. Many answers are still to come. Nowhere have we ever asked so much from every pound of structure. Nowhere have we ever asked so much from every molecule. Rocket nozzles on missiles are subjected 5400°F, but for extremely short duration. An airframe like B-70's will be exposed to 600°F from aerodynamic effects alone, and 1000°F from power plant and aerodynamic effects combined, for as long as 1500 hrs.

Non Metallics—The sustained high-temperatures of Mach 3 flight cause non-metallics to embrittle, crack, and weaken. The B-70 design avoids these materials whenever feasible. But, metals are often impractical, heavier, and more costly to fabricate.

Where do non-metallics hold the advantage? Specifically, which non-metallics are best in a given application? One big area is seals and sealants.

Cabin Sealants—Cabin-pressure requirements in B-70 exceed all previous demands. Allowable leak rate is lower, compartments are larger, operating pressures are higher. (See Table I).

An increase in leak rate of one pound of air per minute (0.072 sq in. hole) requires an increase of nearly 100 lb of refrigeration takeoff weight. The general rule is that every pound of component weight increases aircraft gross weight ten pounds. This means that every pressurization leak equivalent to one pound of air per minute will in-

crease B-70 gross weight nearly 1000 lb.

B-70's crew and electronics-bay structures (riveted and bolted type construction) are sealed by putty-type, elastomer sealant compounds cured in place. Silicone RTV (Room Temperature Vulcanizing) sealants are applied to primed metal surfaces to form fillet or faying surface seals. These sealants must remain non porous and flexible, and conform to structural deflections for the full service life of the air vehicle at temperatures from —65 to over 500°F. Sealants from the following suppliers are being evaluated: Chem Seal, Churchill Chemical, Dow Corning, General Electric, Minnesota Mining and Products Research companies.

Wire Bundle Sealing—Electrical wire bundles which pass through pressurized bulkheads are also sealed with silicone RTV. The bundle is bench-potted where it contacts the bulkhead and then the potted slug is sealed to the bulkhead. RTV silicone elastomer type compounds are used for the majority of electrical potting applications.

For applications above 500°F, ceramic potting compounds of the Englehard Industries CA 9R type, are being considered.

Compartment Seals—Prefabricated, custom molded elastomer seals are used for personnel doors which are opened frequently, for escape hatches which must open easily and quickly, and for escape capsules which must seal automatically. These seals are molded to their installed shape. Connecticut Hard Rubber, who does the molding, uses a material of silicone rubber on a glass-fabric "carcass."

TABLE I

HOW PRESSURIZATION REQUIREMENTS HAVE GROWN

	Cabin Test Press lb/in	Cabin Vol ft³	Cabin Area ft²	Leakage Allowable lb/min
F-100F	5	134.8	83	4.5
T-39	8.8	417	380	7.3
X-15	3.5	150	160	1.6
B-52	7.5	1780	830	14.3
B-70	**10.7**	**935**	**673**	**3.3**

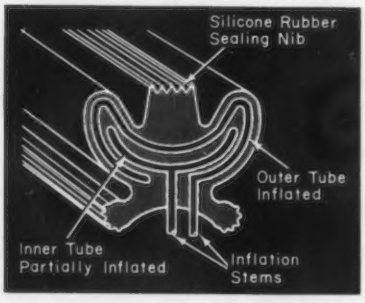


FIG. 1. DOUBLE INFLATION tube incorporated in B-70's seals.

Sealing contact is made by a silicone gum stock nib, extended and positively held in sealing position by nitrogen pressure. For fail safety, a double inflation tube, similar in principle to blow out proof tires with one tube relaxed the other pressurized, is used. If one tube or pressurization system fails, the other will function. (See Fig. 1.)

Because of the amount of flexibility required of these seals, it is expected that they may be replaced every 200 flight hours. The service period before replacement probably will be extended as more data becomes available.

Engine Compartment Sealants—Engine and engine accessory compartments in B-70 are partially pressurized for ventilation and cooling. Riveted and bolted structures are sealed with putty-type sealant compounds in order to maintain pressure differentials, to control fuel, oil, and hydraulic fluid emergency leakage, and to confine flame in case of fire. Sealed surfaces of the engine and engine accessory compartment have long-time service temperatures of over 800°F, so ceramic-type materials are required. Materials used in these areas also serve as firewall sealants. They must not only resist the sustained high service temperature, and the tendency to develop cracks and porosity from extreme temperature cycling and vibration, but also must not burn through when directly exposed to a 2000°F flame for 10 min. Ceramic sealant types being evaluated include CA-9R, Englehard Industries; Sauereisen, Sauereisen Chemical; and Pyroceram Solderglass, Corning Glass Co.

Bulb seals of wire-reinforced asbestos, supported by knitted Inconel and filler, are used in combination with leaf spring seals on engine compartment door where over 800°F is encountered. Johns-Manville Co. is developing the seals.

Bomb Bay and Drag Chute—Seals used in the bomb-bay door and drag chute compartment are bulb-type, custom-molded seals fabricated with a knitted Inconel core contained by an Inconel mesh

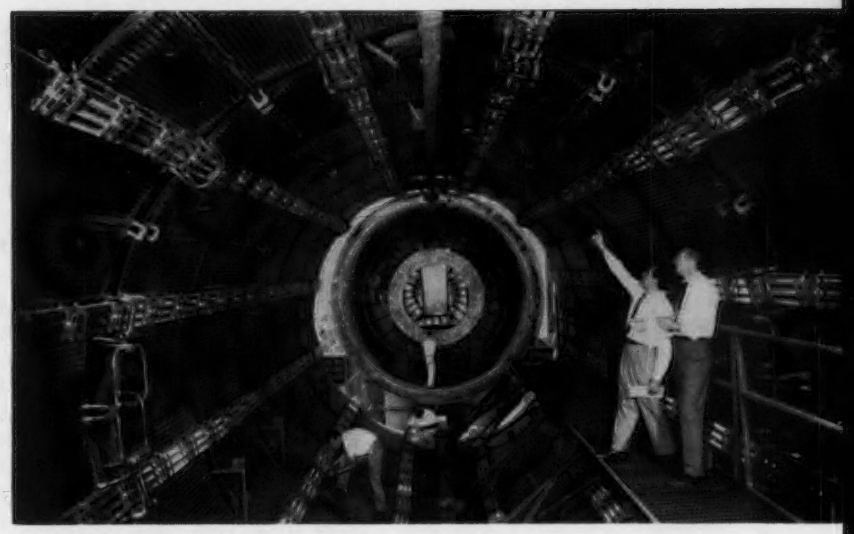
fabric tube impregnated with Viton elastomer and covered by a layer of Teflon. Seals developed by the Connecticut Hard Rubber Co., Los Angeles Standard Rubber Co. and Flexco Inc. are being studied. Maximum service temperatures are over 500°F.

The bomb bay is not pressurized. But, effective door sealing is imperative. This same requirement applies to many other unpressurized compartment doors, even small maintenance hatches, which are exposed to the external airstream. Openings are sealed to prevent external air entering unpressurized compartments. At high speed, external air leaking into a compartment could develop high temperatures approaching the high speed aerodynamic stagnation temperature. Considering the large number of doors and hatches distributed over the airframe such a temperature condition could result in a serious increase in the heat load absorbed by the air vehicle.

Gear Door Seals—Some of the landing-gear-door seals are of the same type as the bomb bay seals. Others are gasket type seals of asbestos impregnated with unsintered Teflon being developed by the Johns-Manville and Raybestos Manhattan companies for the over 500°F environment of the landing gear doors. The Teflon is used unsintered to provide the low resistance to compression necessary for compliance to the door sealing surface.

Aerodynamic Seals—Most aerodynamic seals are of the bomb bay door seal type. Other stationary and moving aerodynamic seals are of the wiper type. They were developed by the Connecticut Hard Rubber Co., and are built up of laminations of glass fabric cured in silicone elastomer and covered on the rubbing and high temperature surfaces with Teflon. Environmental temperatures range to over 550°F.

Bulb seals, with various cross sections, of glass fabric and silicone elastomer, hollow or filled with knitted Inconel mesh, are used for weather seals in over 500°F environments. Weather seals are generally used outboard of and in addition to the other seal types discussed. Many are covered with Teflon, either for lubrication, or for increase in temperature resistance. Seals under consideration include those from the Connecticut Hard Rubber, Los Angeles Standard Rubber and Kirkhill Rubber companies.



PRESSURIZED COMPARTMENT for B-70 crew will be tested as a unit in 70-ft (useful space) chamber. Materials and systems will be evaluated at simulated environments of −90 to 1000°F, and 140,000 ft altitudes.

Aerodynamic Smoothers—Smoothness requirements of the B-70 allow gaps and projections of only a few thousandths inch in critical areas. Compounds for fairing corners and filling cracks in structural joints around fasteners, etc., must adhere well through temperature range of −65 to 600°F. In addition, the thermal expansion coefficient must be close to that of the metal so that the crack filling and smoothing material will not project at high temperature or recede at low temperature in excess of allowable discontinuities. Silicone RTV elastomer compounds tested to date have excessive thermal expansion characteristics. Sprayed metal requires abrasive blast of the airframe surface to obtain adhesion, builds up thickness slowly and must be finished smooth by grinding. A proprietary ceramic composite compound, Englehard Industries, CA 9R, which has adequate thermal properties and is applied after only a solvent wipe of the metal surface is currently under evaluation. The application process for this compound does require baking for one half hour at 450 to 500°F.

Electrical Insulation—Extruded Teflon, or a combination of extruded Teflon and glass fiber braid, is used for insulating electrical conductors for extended service at maximum temperatures to over 600°F.

A proprietary process, by the Kingsley Machine Co., for heat sealing of identification markings to the Teflon insulation is being evaluated. These markings are permanent and can be identified after prolonged exposure to 700°F.

Electrical conduit of extruded Nylon tubing is planned for use in areas with maximum service temperatures of 250°F.

Very small extruded seals of silicone elastomer sponge of the type manufactured by Hadbar, Los Angeles Standard Rubber and Haveg, are used for control of cooling airflow through various electronic equipment. Service temperatures are approximately 250°F.

Flexible connectors for cabin environmental control system ducts up to a 10 in. diam are molded of glass fabric and silicone elastomer by Flexco, California Rubber Products, and Arrowhead Products com-

panies. These connectors are tested to 20 psi at 300°F.

Tires—Because of the very high flexing rates combined with high impact, shear and tension loading, B-70 tires are made of natural rubber and Nylon. The tires are tubeless and are carried in landing gear wheel wells cooled to 250°F. Development is under way by the B. F. Goodrich Co. to provide tires with higher temperature resistance in order to reduce the cooling load. The magnitude of the B-70 tire problem is immense. Goodyear Tire and Rubber Co. says: "The 56 x 16 tires used on the B-52 have 603,000 foot pounds of potential energy stored in each tire. This is sufficient energy if properly channeled, to put a piece of tread the size of a golf ball into orbit." B-70 tires must meet load, energy, and dynamic requirements exceeding those of the B-52.

Fuel System Seals—"V" cross section seals of stainless steel developed jointly by Hi-Temp. Rings, Inc. and North American Aviation, Inc., are used for the majority of B-70's fuel system seals. These seals are manufactured by both the Hi-Temp Ring Co. and Servotronics. Although made of metal, a non-metallic material is essential to their function. Each metal seal is covered with a layer of Teflon. Without the Teflon both the seal face and the surface of the part to be sealed must have a very fine lapped smoothness. With the Teflon, reliable sealing over the temperature range of –65 to over 550°F is obtained with mass production machine finishes. This technique is more economical than using fine lapped surfaces.

Viton O-rings are used for some fuel system sealing applications. These seals are serviceable up to 500°F but are expected to be replaced after approximately 300 flight hours.

O-rings of Viton and silicone are used for various sealing applications as the liquid exposure environment permits. O-rings suppliers include the Hadbar, Rubber Teck, Parker Seal, Stillman Rubber, and Pacific Molded Products companies.

Integral Fuel Tank — Integral fuel tanks are sealed by the structural assembly methods, welding and brazing in the main. However, non-metallic materials are being developed to provide secondary and supplementary sealing as necessary. During test evaluation, coating sealants based on Viton A-HV and Viton B have sealed against 50 psi after fuel soak and temperature cycling including 1000 hr in JP-6 vapor at over 500°F. Non-metallic fuel sealants of various types are under development by material suppliers to meet these extended service life requirements. Most active in this area are the Products Research Co. and Minnesota Mining and Mfg.

NAA test evaluations have shown that under conditions of B-70 fuel tank operation, fluorocarbon materials can be made to last much longer than indicated by generally published data.

Insulation of certain areas of the fuel tanks prevents local boiling of fuel. Materials problems are analogous to those of fuel sealants since the insulation is applied to the fuel wet side of the tank structure. Insulating materials based on fluorocarbon elastomers with light weight filler materials have been subjected to temperature cycling equivalent of 600 flight hours without failure.

Fuel Tank Access — Silicone O-rings are used for sealing fuel-tank access doors. Silicone compounds are not generally considered to be fuel resistant. When confined in an O-ring groove, however, O-rings of Union Carbide Co. silicone molded by Rubber Teck Inc. provide the longest combined fuel soak-high temperature service life of any available O-rings. It is expected that O-rings of this type will be available from the Rubber Teck, Parker Seal, Hadbar, and Stillman Rubber companies. A service life of several hundred flight hours is expected.

Dielectrics—Major uses of reinforced plastics are for the various radomes, antenna covers and electrically insulated structural members of the weapon system. Different resins used include Monsanto phenylsilane, Naugatuck Vibrin high temperature polyester, and Dow Corning silicone resin. Combinations of these resins will be used with glass fiber and other high temperature resistant reinforcing agents to obtain the particular balance of structural and electrical properties required by each radome or electronic transparency at its operating temperature. Precise compromises between electrical and physical properties as affected by temperature, are necessary. Maximum operating temperatures range to over 600°F for different installations. Those which present leading edges to the airstream are designed for easy replacement. Rain erosion studies are part of the B-70 program and include rain erosion tests on the rocket sled at speeds up to 800 knots.

Adhesive Bonding — Although precluded from some structures by long-time, high-temperature environments, adhesive bonded structure is utilized in several areas of the B-70.

One of the more interesting applications is the structural bonding of electronic racks with service temperatures of 250°F. A special NAA developed conductive adhesive is used to provide a better electrically conductive path than riveting and jumper bonding, as well as a lighter, more compact structure. Where electrical conductivity is not required, Rubber and Asbestos Corp. Bondmaster M-611 is used.

Other applications include bonded aluminum honeycomb panels in the escape capsules, bonded joints in fuel lines and in electrical conduits. Bonded silicone resin glass honeycomb panels filled with glass fiber insulation are bonded to wheel well doors for thermal insulation purposes.

Windshield — The windshield and related transparent panel installations present formidable problems at Mach 3. The B-70 crew compartment has nearly 100 sq ft of glass. This is a large area of transparent material for a high performance aircraft. All transparent panels, the largest over 6 ft long, are of optical quality, heat resistant, tempered plate glass. Service temperatures of some panels are nearly 500°F.

B-70 aerodynamic contour requires severe slanting of windshield panels to obtain near grazing airflow. The resulting high angle of optical incidence between the pilots' line of vision and the transparent panel magnifies optical defects in the panel. Rigorous optical distortion standards for aircraft glass have been established and have been accepted by the glass suppliers. Processes and quality control procedures to meet these standards, very difficult to attain in large, heat resistant panels, are being developed by the Libbey Owens Ford, Pittsburgh Plate, and Corning Glass companies. Appreciable weight saving is accomplished by designing many of the panels to carry structural loads and serve as part of the working fuselage. Structural edge attachments are bonded directly to the glass to carry these loads. An organic adhesive developed by the Minnesota Mining and Manufacturing Co. and a ceramic adhesive developed by the Corning Glass Works are used, depending on the service temperature, for edge attachment to glass bonding.

For fail safety, all panels carrying the 10 psi cabin pressurization loads are laminated. A new high temperature resistant interlayer, silicone Type K, developed by the Dow Corning Corporation, is used to bond the glass laminations.

Transparent, conductive coatings developed by the glass suppliers are used to prevent windshield fogging under adverse humidity conditions.

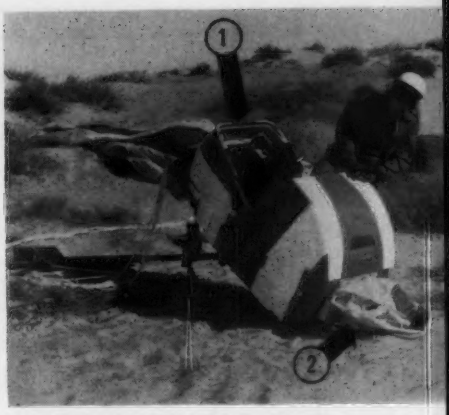
Ceramic Materials—A novel use of ceramics on the B-70 is for wear resistant coatings on hydraulic actuating cylinder piston rods. High wear resistance is necessary because of the interference fit type seals used for the high temperature hydraulic system. The ceramic coating is flame plated by a proprietary process developed by the Linde Co. Molten ceramic particles are explosively deposited as a continuous coating on the piston rod.

Various ceramics are used for electrical insulation. These include glass bonded mica (Mycalex Corp., Electronic Mechanics, Inc.), and glassy coatings deposited as glass frits (Corning Glass Co., Ferro Corp.). A new coating application is the use of the National Bureau of Standards A-418 ceramic as an internal insulation coating for electrical conduits.

Thermal Insulation—Crew and electronic compartments are insulated with glass fiber batts of silicone resin bonded "AA" glass fibers (0.00004 in. fiber diam) of 0.6 lb per cubic ft density. Batt thicknesses vary from 3 to 5 in. Aluminum facings are used to protect the batts from mechanical damage during installation and to reduce heat transmission by radiation. This combination provides a lower rate of heat transfer per pound of insulation than any other insulation system considered practical for use around crew and electronic compartments. Sufficient insulation is installed to couple with the cabin environmental control system in maintaining an internal wall temperature of 70°F with an external wall temperature of over 500°F.

For areas where space limitations control (landing gear wheel well, around fire extinguisher bottles, etc.), Johns-Manville "Min K" is being considered. The conductivity of "MinK" having a density of approximately 16 lb per cubic ft is about 1/3 that of glass fiber batt of equal thickness. A proprietary material, "Min K" appears to be a composite which includes specially prepared silica, asbestos fibers, a black opacifier, and a binder.

For insulation in temperature environments from 700 to 1000°F, "B" glass fibers (0.00013 in. fiber diam) formed into batts without binder, are selected. For the limited number of applications above 1000°F felted silica fiber batts are necessary. These are used to protect actuators and other accessories against engine heat.

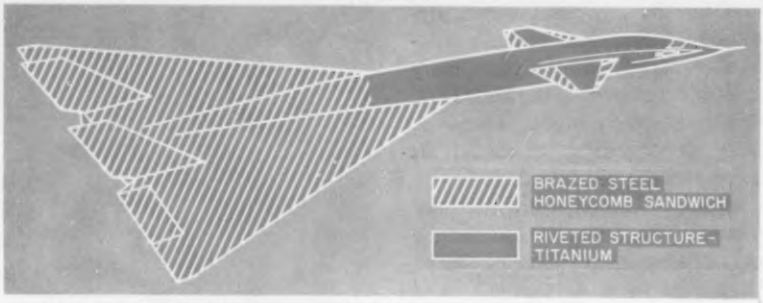


ESCAPE CAPSULES in B-70 use inflatable seals (1). Landing shock cushions and flotation bags (2) are of neoprene-coated nylon fabric.

Drag Chutes—Nylon fabric is the best material available with sufficient energy absorption capacity for use in drag chutes to shorten the landing roll. Present plans are to cool the drag chute compartment to 250°F. Since the thermal degradation of nylon in this temperature range occurs chiefly by oxidation, studies are under way to raise the drag chute compartment allowable temperature by excluding oxygen from the drag chute high temperature environment. Drag chutes have a relatively short service life because of mechanical damage resulting from contact with the runway following deployment.

Vehicle Fluids—Fluid quantities vary from thousands of gallons of JP-6 fuel to a few ounces of silicone instrument damping fluid.

The improved thermal stability of JP-6 compared to previous aircraft turbine fuels has materially reduced varnish and coke formation problems. Small amounts of contamination have appeared on equipment during high temperature fuel system studies. An anti-icing fuel additive (Phillips Petroleum Co. 55 MB) appears to have some dispersing effect on the products formed by thermal decomposition and will



TREND-SETTING B-70 uses chiefly stainless and titanium in structures.

be the subject of continued investigation.

The various auxiliary power systems are lubricated with MIL-L-9236B lubricating oil. Development efforts are being continued by the Hayden Newport and Celanese chemical companies to improve the load carrying capacity of lubricating oils without undue sacrifice of other properties.

The hydraulic fluid is a disiloxane type fluid developed by the Oronite Chemical Co. Major problems with hydraulic fluids include high temperature stability and viscosity control over the extreme temperature range from – 65F to over 450°F.

Lubricants — Lubricants, apart from lubricating oil, present another non-metallic material problem area for Mach 3-flight. There are on the order of 2500 bearings, excluding engine and engine accessories, but including plain, anti friction and other types, on the B-70 airframe. Many of these bearings are relatively inaccessible and must function for long periods of service even though service temperatures may stabilize at over 600°F. Only one grease, a highly chlorinated silicone oil and lithium soap compound by the Dow Corning Co., was found satisfactory for up to 150 hr at 450°F. Greases available for service above 450°F are not acceptable for the B-70 because of their excessive break out friction characteristics.

For up to 550°F service, Fabroid bearing liners have been selected for lubrication of plain journal and plain spherical bearings. Various power system bearings are of the plain type and include linkages powered by the hydraulic system, actuator attachment bearings, primary control linkages and hinges, and landing gear and other high load carrying pivot points. The Fabroid proprietary lubricating material consists of glass and Teflon fibers interwoven into a fabric. One side of the fabric presents low friction Teflon to the rubbing surface and the other side exposes sturdy glass fibers for adhesive bonding to the bearing shell.

For service over 550°F, dry film lubricants and replaceable bearings are necessary. Dry film lubricants include molybdenum disulfide and graphite. Resinous and sodium silicate binders are used. Because of corrosion problems, new binders based on silver resinate and titanate are being considered. Available dry film lubricants give characteristically short service of 15-20 hr at 700°F. The Everlube Co. is currently active in the development of improved film lubricants. An NAA developed process for chemical milling to form many tiny pockets in the bearing surface to retain lubricants has more than doubled the service lift.

METALLICS

The first complete B-70 will climax more than 14,500,000 engineering man hours.

Investigation of adequate metallic materials and processes have taken their share of these hours. And, the non-metallic people have surely not been alone with the materials problems of Mach 3 flight.

In designing B-70, range was the desired factor. It dictated the other two valuables, speed and altitude. To meet the range requirements a delicate balance of speed and altitude was needed. These broad parameters (intercontinental distance, 70,000-ft altitude, 2000-mph speed) established structural requirements.

It was necessary to allow for a huge supply of fuel to feed six mammoth J-93 engines. A welded construction, using skins of the aft fuselage and wing as integral fuel tanks was almost an immediate design direction. The long-time, high-temperature environment pointed to high-strength steel and titanium alloys as the major structural materials. Engine - compartment temperatures up to 1600° F pointed to nickel and cobalt-base superalloys for internal structures.

Honeycomb—Steel-honeycomb-sandwich fabricated by brazing, was selected for areas carrying maximum structural loads and high skin temperatures of 400 to 630° F. Honeycomb construction was selected because it provides optimum structural efficiency and excellent thermal installation.

The B-70 sandwich consists of facing sheets and honeycomb core of corrosion resistant PH 15-7 Mo steel with specially designed edge members and fittings. All of the sandwich components are joined with silver-base brazing alloys (Handy & Harman).

Stainless Steel Sheet—PH 15-7 Mo stainless steel sheet for the B-70 is rolled on a Sendzimir mill. It is then stretch-leveled. Tolerance requirements are ± 0.001 in. for sheet up to 44 in. wide. Flatness and finish requirements are also critical.

The sheets go through a number of processes before they are ready for brazing. The density of steel in aircraft structure requires that excess metal be removed even in localized areas. This is done by chemical milling, common machining, and grinding. Some structures are pocketed to severe depths and others are tapered.

Parts are also machined from plate, bar, and extrusion. AM 355 (Allegheny Ludlum Steel Corp.) is used along with the PH 15-7 Mo steel in these applications. AM 355 is used where stock thicknesses exceed ½ in. Excellent advantage of its transverse ductility can be realized in these areas.

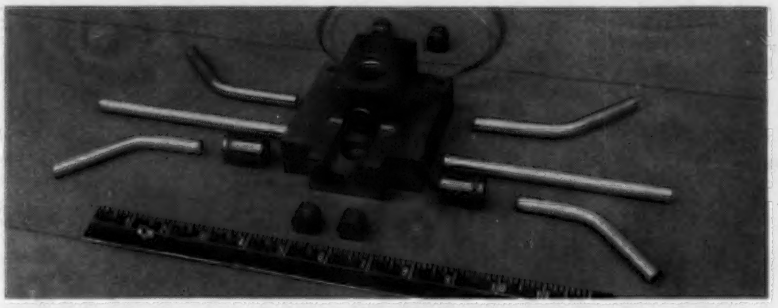
Honeycomb Core—The honeycomb core used in B-70 is fabricated from PH 15-7 Mo foil. It is 0.00075 to 0.004 in. thick. The tolerance limits for the foil are 5 per cent of the nominal thickness. This means that the tolerance on a 0.001 in. foil would be ±0.00005 in.

This product, developed specifically for the B-70 by the Wallingford Steel Co., is also made on a Sendzimir mill. The foil is produced in widths up to 23 15/16 in. Foil is made into honeycomb core with square-shaped cells ranging in size from ⅛ to ¼ in. The depth of the core is extended by joining the cells at their corners with intermittent resistant welds. The welded zone is called a node and is the most important part of the core structurally.

Core material is made by one of two methods. In the first, strips are performed then welded. In the second method, called HOBE, welding is done in the flat. The core is then expanded to obtain correct cell configuration.

Brazing Alloy—The brazing alloy used to join the facings and core of the B-70 sandwich must meet a number of difficult requirements. To meet these, NAA's Los Angeles Div. work hand-in-hand with the research staff of Handy & Harman. The brazing alloy they developed has a silver base (84.6 per cent) and it brazes at 1725°F. About 5.5 per cent Indium is added to reduce the high thermal conductivity characteristic of silver. Palladium (2.2 per cent) is added to raise the brazing temperature to that required for the first stage of heat treatment in the PH 15-7 Mo steel. It also makes use of 0.2 per cent lithium for self-fluxing.

Titanium — Titanium alloys are used extensively in the forward fuselage and in the horizontal stabilizer of the B-70. These areas are not fuel containing. Skin and frame-type structure with mechanical fasteners is therefore used. Flight temperatures of about 550°F are encountered in these areas.



BRAZED HYDRAULIC COMPONENTS are a trend that will be followed in vehicles beyond B-70.

Two heat-treatable sheet alloys are used: 6AL 4V sheet for welded parts; 4AL 3Mo 1V for parts requiring maximum formability. Sheets are chemically milled to achieve the required thickness tolerance of +0.000 to —0.002 in. Both alloys are used at a tensile strength of 160,000 to 190,000 psi.

H-11 Steel—H-11 steel is used in many internal structures of B-70 fuselage, wing, and horizontal stabilizer. Landing gear mechanisms also make use of this 5 per cent Cr, air hardening material. Heat treatment gives a tensile strength of 280,000 to 300,000 psi.

Some H-11 parts require threading, straightening, or grinding. Each process is a potential trouble spot. Some of the limitations followed on B-70 are:

- Grinding — All grinding is followed by 925°F stress-relieving for 2 hr.
- Threads — All MIL-S-7742 threads must be rolled. Acme, Whitworth, or "radius root" threads may be ground or rolled.
- Welding—Preheat and post-heat treatment is mandatory. Welds are made at a temperature of 600°F.

Following these rules will save a lot of corrective costs.

H-11 steel parts are protected from corrosion in several ways:

- Sprayed aluminum coat with silicone resin for environments up to 900°F.
- Nickel-zinc electroplate coated with silicone resin as an alternate for same service life.
- Vacuum deposited cadmium for environments less than 500°F.

Brazed Hydraulic Lines—B-70's hydraulic system operates at 4000 psi and 450°F. It consists of AM 350 tubing for lines, AM 355 and H-11 steels for fittings and components.

The tubing alloy was developed by Allegheny Ludlum. Wallingford Steel Co. and Trent Tube Co. produce it in a special tempered form. The tubing is made by fusion welding the strip, cold drawing, with intermediate anneals, then cold drawing to reduce wall thickness about 30 per cent.

The hydraulic system arrangement requires about 5000 joints to install the tubing. They must be light and strong as possible. Induction brazing with machined sleeves is used to meet requirement.

Assembly by brazing also saves weight in fabricating hydraulic cylinders and valves. These are made of H-11 steel, brazed to AM 350, AM 355, and Type 321 details. The high modulus of elasticity of H-11 steel is used to good advantage. It minimizes deflection of cylinder walls under high pressure and permits good seals to be maintained between pistons and cylinder walls.

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The Supersonic Transport— For Prestige or Profit?

- *Management faces host of technical, business, and political problems in SST:*

(1) Can we afford to be second to Russia with the Mach 3 airliner?

(2) Can we ask or expect private enterprise to assume the development costs?

(3) Is government financing the answer?

(4) How fast, how high, how far should the SST fly to make money?

(5) What is the market? What is the need?

Here are industry's views:

by Philip Geddes

Time or not, right or wrong, we will build a supersonic transport. Its general operating characteristics can be determined now. But, who will pay for it? Over what routes will it operate? When will it be ready?

Whether the airline systems want it or not is being ignored at this point in face of the argument that "national prestige" will be lost if someone else produces a supersonic transport before the U. S. Under government sponsorship, the movement to build has started. About $12 million has been pumped into the FAA kitty.

Aircraft manufacturers who could be expected to take part in a design and building program have been talking supersonic transport for two years. There are many problems to be solved. Money enjoys a top spot among them. U. S. airlines have a dollar turnover of $5 billion annually. About $3 billion has been invested in jet-age equipment by the airlines. But profits have not been high. Trunk line for example netted only $4 million on $2 billion revenues.

Financing SST—The question of finance is dealt with no uncertainty by Convair who is on record as saying, ". . . the SST program is not feasible for private investment. The program is feasible for manufacturing if the government underwrites the development costs. Such funds need not be regarded as a subsidy but as a non-interest bearing loan. The investment would be recovered as production aircraft are delivered to the carriers." Convair believes that the supersonic transport program is "ideally a one-manufacturer program."

Boeing, Convair, Douglas and Lockheed have openly discussed the subject of SST. North American Aviation is keeping quiet, apart from pointing out the experience they and others will gain in B-70.

Why Mach Three?—How fast? Mach 2, 2.5, 3, or more goes the Mach number game.

The answer is not simple. Yet, all the potential manufacturers agree the fear of rapid obsolescence alone eliminates Mach 2. The only opposition comes from the British who advocate a two-step approach to Mach 3+. A Mach 2 transport could be a-building right now, they claim, and in the air by 1965, judging by the average civil transport development time (over last 15 years) of 4.8 years.

The biggest thorn in the side of Mach 2 after the fear that this speed would be topped too quickly, is that a Mach 2 dry unaugmented turbojet engine is less efficient vis-a-vis overall propulsion efficiency than the Mach 3 engine. Cut short, this topic boils down to—today's engines are more suitably adapted to Mach 3 than to Mach 2, and that the latter speed would require a major engine development program to achieve the desired effi-

ciency in cruise. Development cost and initial cost of the higher speed transport are higher than the Mach 2, but the direct cost in cents per seat mile is lower at Mach 3 according to the Lockheed chart:

CRUISE SPEED SELECTION

3500 naut. mile with equal payload

Ratio for comparison	Mach 3.0 / Mach 2.4
Development cost	1.24
Takeoff Weight	0.99
Initial Cost	1.23
Cents per Seat Mile	0.95
Block Time	0.84

Lockheed attributes this lower direct operating cost to the 16 per cent higher block speed and improved Mach 3 fuel economy overcoming the higher initial cost. And according to Boeing, the operating cost tends to level off shortly above Mach 2 and it appears fairly difficult to obtain any significant improvements beyond Mach 2.5 region.

Convair's market summary for a supersonic transport concluded that there is no clear advantage, either in operation or economics, for any design cruising speed between about Mach 2.0 and Mach 3, provided airplane life is a minimum of 30,000 hours. (See Fig. 1.) They add that steel or titanium built planes would provide "a built in stretch" which would allow modification of the airplane to permit greater speed in line technical

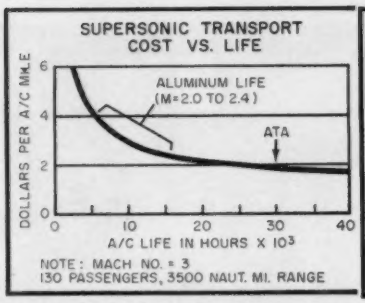


FIG. 1. MINIMUM LIFE of supersonic transport is established by Convair at 30,000 hr.

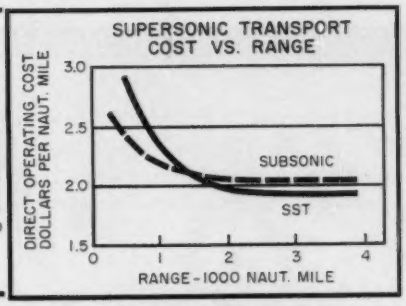


FIG. 2. COST PER MILE reaches a crossover point for subsonic transport and SST at 1500 naut mi.

improvements. Each time we come back to Mach 3.

How Far?—Range requirement seems to be pretty well established at not less than 4000 statute miles. There is general agreement among manufacturers that cost per mile for above 1500 nautical miles is lower than that of the subsonic jet. On shorter ranges the cost is appreciably higher. (Fig. 2.) The reason being that the supersonic transport would use much more fuel than the subsonic in climbing and accelerating. Boeing says that the selection of design range and payload will have to be a compromise to arrive at a transport useable over widest possible international route structure, no one will disagree with that. Increases of range require substantial increase of payload to keep seat miles constant.

How Big?—Next we have size. Should the SST carry 50, 100, 200 passengers? In each company's analysis of the Mach 3 transport, there is reference to the estimated growth of airline miles to be traveled over world routes up to about the year 1975. (Fig. 3.) Lockheed predicts total common carrier traffic to rise 2 per cent per year. This is based on a penetration of the total travel market for 10 to 50 per cent in the last 14-year period reviewed. Penetration is expected to increase to 70 per cent by 1975. Convair predicts that the available traffic in 1975 will be much higher than the Lockheed prediction and says, "Convair's forecast is lower than several other published forecasts."

The point under discussion, however, is size, and size goes hand in hand with frequency. Lockheed foresees a fleet of 60 to 80 place Mach 3 airplanes operating at high frequency by 1965. Convair disagrees.

continued on next page

Potential Supersonic Aircraft Market

(median 2,900 st. mile range, 65% load factor)

	Mach. No.	70 passenger aircraft	100 passenger aircraft	130 passenger aircraft
1965	2.0	199	141	108
	2.5	171	121	93
	3.0	154	109	83
	3.5	143	101	77
1970	2.0	276	195	149
	2.5	237	168	128
	3.0	213	150	115
	3.5	198	140	107
1975	2.0	346	245	187
	2.5	298	211	161
	3.0	267	189	145
	3.5	249	176	135

CONVAIR ANALYSIS of SST market indicates requirements will peak in 1975. Convair believes it is a one-manufacturer market.

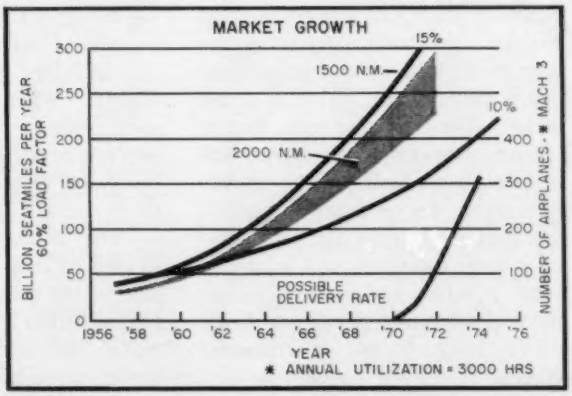


FIG. 3. MARKET GROWTH is shown in Boeing chart. Top line, 15 per cent growth rate, all traffic over 1500 mi. Bottom, same traffic at 10 per cent growth.

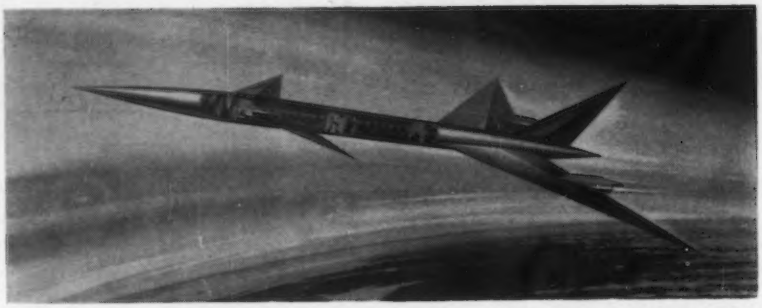
They favor a larger Mach 3 airplane seating at least 100 and probably up to 125 passengers in order to serve the 1965 to 1975 market. Full fleet strength by 1965 as envisioned by Lockheed is not expected. Convair sees the first SST's operating initially only on the high-density prestige route segments before the 125 place plane moves into secondary markets by 1975. Convair's market study is critical of the 60 to 80 place plane as follows, "It is apparent that a 60 to 80 passenger aircraft is too small for the major routes, even at 1960 levels."

Boeing envisions a larger passenger airplane being the most efficient and Douglas has spoken of a 160 passenger Mach 3 study. The paper studies, so far, then result in a generally accepted airplane larger than the Lockheed 60 to 80 passenger machine.

What Configuration? — Brochuremanship and technical crystal ball gazing are simple arts compared to achieving a practical, safe, optimum design. However, the ideals detailed here are from the people who will design and build the Mach 3 transport. They have given it some study.

The world is not about to go for another round of runway lengthening to get faster airplanes on and off the ground. Therefore, the primary operating requirements of the Mach 3 transport revolve around subsonic operating criteria in the airport vicinity, without prejudicing cruise performance. This is a tall order. The manufacturers find a canard arrangement attractive. But full details are lacking. The canard, it is said, demonstrates a negligible drag penalty for the aft center of gravity condition and relatively small penalties with forward movement of the center of gravity. Critical stability occurs at transonic speeds.

The stall speed must be low and the lift-curve-slope must be high to achieve reasonable landing and takeoff speeds and distances.



LOCKHEED DESIGN is radical and aimed at Mach 3 to 3.5. On a 200-plane production schedule, the airliner would cost about $10 million each. Would gross about 250,000 lb.

However, high lift devices on the leading edges and the trailing edges are not easily reconciled with the extremely thin, sharp-edged, highly-swept wings which are required for low drag at cruise. The supersonic plane unlike its subsonic counterpart must use wings of low aspect ratio and high sweep. Boeing predicts an aspect ratio in the range of 2 to 3 rather than 8 to 9 as is now common.

Some NASA researchers suggest that it is impossible to lower landing and takeoff speeds with low-aspect-ratio wings designed for high speed cruise. This group was encouraged by wind tunnel results to suggest variable sweep wings.

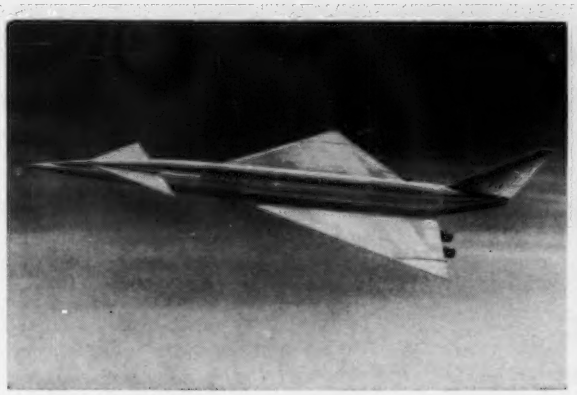
Boeing suggests other design solutions to overcome the disadvantages of the supersonic wing during low-speed flight. These include the use of boundary layer control, flap blowing, jet flaps, and lifting engines. Whether one of these or some other solution will provide the best compromise is currently one of the major research items related to the supersonic transport.

The fuselage will be needle shaped to keep drag low. The design of the passenger compartment ranges from being hermetically sealed without windows, but enjoying the passing scene on television, to having windows but still being crammed in a much smaller space than enjoyed at present. The large aerodynamic-heating load imposes high loads on the airconditioning system. But, the same percentage of gross weight as currently used appears to be obtainable. As with any other system on the SST, failure imposes very sharp limitation on the operational profile, with respect to range, height, and speed.

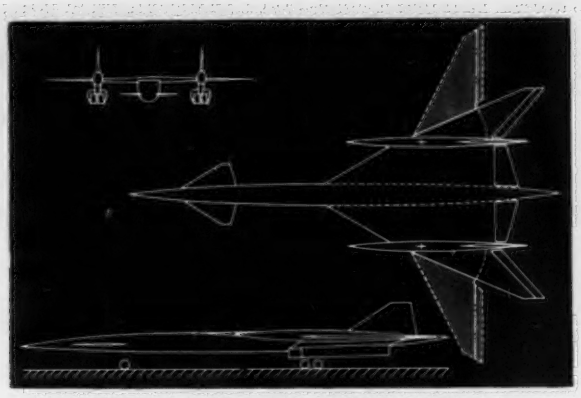
What Powerplant?—There was considerable optimism in early estimates of engine cost. Later work shows that engine costs mount with the Mach number due to the use of expensive, high-temperature materials and design problems.

As to engine layout, a Pratt & Whitney source claims the dry turbojet without afterburner has the highest efficiency up to Mach 3.0. An afterburning turbojet has the lowest specific weight but a high cruise fuel consumption. In reviewing the powerplant field, including hybrids, it is obvious that no one unit possesses a clear advantage over the others. But the facts will have to be sorted from a pile of claims by the interested parties. Positioning the engines is still as debatable a matter as the choice of engine type. In that same category goes the choice of inlets.

Since fuel will account for a considerable percentage of operating costs it is essential that this be something like today's fuel at today's prices. Current jet fuels are



BOEING DESIGN is window-less. This is a prevalent design concept for the supersonic transport. TV screens would give passengers a view outside the plane.



VARIABLE SWEEP CANARD has been proposed by NASA for supersonic transport. Thin, high-speed wings are not compatible with low-speed operations.

held unacceptable for Mach 2 to 3 commercial operation by Boeing.

Which Materials? — Here the choice is simple compared with the other areas discussed but the cost is high. Aluminum was discarded with the desire to exceed Mach 2 plus, leaving stainless steel and titanium.

It should not be forgotten, however, that the structure of the Mach 3 airplane has to be guaranteed for a minmum of 30,000 hr to achieve reasonable operating cost. The B-70 will undoubtedly offer much information on manufacturing and material problems, both metallic and non-metallic.

Is There a Market?—A representative opinion about the market for a Mach 3 transport comes from Douglas: "The airlines will purchase a new airplane only after they are convinced that they can operate it at a profit . . ."

But what of profit to the manufacturer?

The profit to be made depends on the market, Convair as noted previously considers it a one manufacturer market. Their analysis for the market is shown in table on page 33.

Cost for the Convair Mach 3.0, 130 passenger, 4000-mi range aircraft turns out at a low basic price of $11.8 million per unit with a total price including engines and radio, of $14.1 million per unit. These figures are based on 145 total deliveries and 20 per cent profit. The estimates do not include the possibility of extensive redesign in the program.

Douglas estimates that the Mach 3 transport could cost anywhere from present going prices to 3 times that much.

The Boeing figure for cost analysis purposes is $11.3 million for a Mach 2 airplane. They feel the aluminum, Mach 2, machine can be priced accurately from existing knowledge in subsonic production.

Lockheed predicts cost for 100 250,000-lb Mach 3 airliners at approximately $11 million each with $160 million taken in development funds.

That there is hesitation of talking cost in a supersonic transport program is not unexpected. Convair in this regard gave a frank opinion on aircraft price and return on investment in an appendix to their supersonic market analysis.

"It is believed that a rational program can be instituted to provide sufficient flight experience before commitment toward a final SST design. Such a program should establish supersonic boom criteria, provide experience, and remove questions in the piloting area, supply FAA and legislative groups with sufficient background for final standards, and generally reduce the risks during the development cycle. Without such a program, it is entirely possible that the total nonrecurring cost for the program could be more than doubled.

"The price of the delivered aircraft, consequently, could well be in the area of $17 to $20 million rather than the $14 to $17 million . . ."

Convair does not see investors falling over themselves to invest money in the supersonic manufacturer. The test program from prototype to certification is anticipated to require about four years to complete. The result is that one-half billion dollars or more will have to be set aside over a period of seven to ten years before any return at all is realized."

"This is the reason for the manufacturer's reticence in entering the program. If, however, the government helps the manufacturer by carrying the burden of the long-term development costs, the program becomes more attractive."

The conclusion is sad but inescapable. If the Government is convinced that a supersonic transport is indispensable to the prestige of the United States, the Government will have to pay for it, and take back what it can.

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Cockpit Automation For Mach 3+

- **Speedy decisions, optimized responses are musts for supersonic flight. Delays will cost $3000 an hour**
- **Man must have an airborne computer-center to collect, integrate, and display diverse systems data.**
- **What will computers be like in the SST? What kinds of jobs will they do?**
- **How far can we logically allow 'computers' to take us toward a Mach 3 drone?**

by John P. Kushnerick

Electronic computers have space reserved aboard the supersonic transport. How can such a flat statement be made?

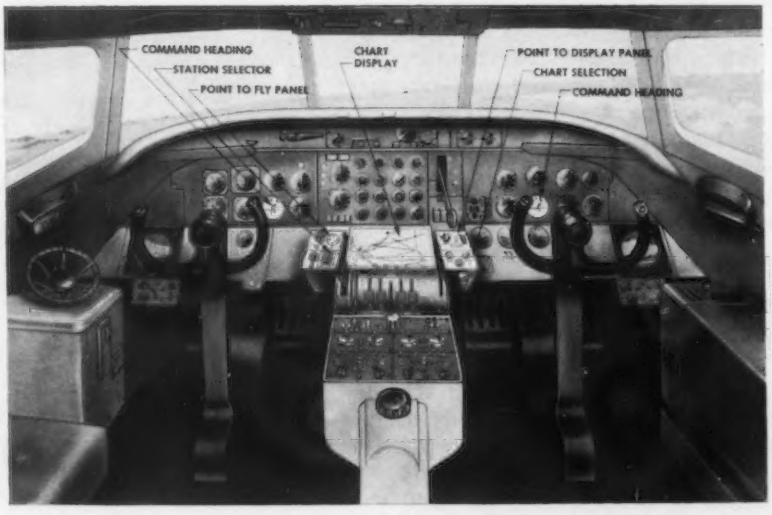
Two needs override all others in the Mach 3 transport. It must operate safely. And, it must operate economically. The degree that these two requirements are met after the airplane is delivered rests with FAA, airline, and pilot.

Unprecedented volumes of data will have to be collected, evaluated, and displayed in supersonic flight. The aircraft will have to respond immediately and precisely. The pilot will have to know about many things before they happen in order to react in time. Much of the data will have to be anticipatory. How will it all be done? Nothing short of airborne digital computers could integrate and manage the diverse systems inputs and outputs. And there may be a large central computer to act as an electronic manager for smaller devices.

Roles For Computers — The main question is this: "How far toward a guided drone can we allow the SST to go?" There must be judicious restraint. A reasonable trade off must be made between the speed and accuracy of a computer and the judgment and interpretative ability of the pilot.

What tasks can we logically expect computers to perform or supplement?

- Preflight check of systems
- Speed and altitude
- Automatic navigation
- Systems monitor and test inflight
- Anti-collision systems



- Air-to-ground-to-air communications (AGACS)
- Automatic landing

What Kinds of Computers?—What will the computers look like, and be made from? The trend in airborne digital computer design is toward smaller, lighter, more versatile, and more reliable equipment. The first computers were vacuum tube designs. The current devices are all-solid-state using germanium and solicon components. Their degree of reliability is one order of magnitude better than tube-type computers. Considering the time era of the SST, the computers used in this aircraft-breed will be as different as the solid-state computers were from their tubed ancestors.

Film devices will replace much of the existing circuitry. There are three reasons for this:

- Reliability—Thin-film components (capacitors, resistors, and interconnectors) are inherently very reliable.
- Integral design — Thin-film computer circuits minimize the number of interconnectors. These are basically a weak link in the reliability chain.
- Size—Thin film component thickness is measured in Angstroms. This allows a great deal of redundancy without serious compromises in weight.

Electronics Management—The economic necessity of speedy decisions and optimum flight paths takes on new meaning in Mach 3 flight. Time delays will cost $2000 to $3000 dollars for every hour the aircraft is in operation.

One concept for achieving safety and economy is called CEMS, Central Electronics Management System. It is proposed by Hughes Aircraft Co., and is descriptive of its function. CEMS will use a central digital computer to integrate and optimize all of the functions now being performed by a variety of subsystems and crew members. The advantages of CEMS are outlined in Table I. The military has provided the development impetus.

(Continued on next page)

Table 1

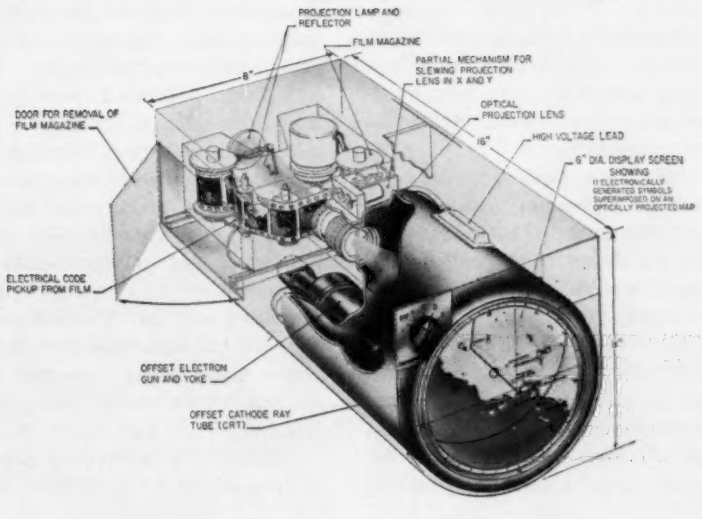
CENTRAL ELECTRONICS MANAGEMENT SYSTEM
for the supersonic transport

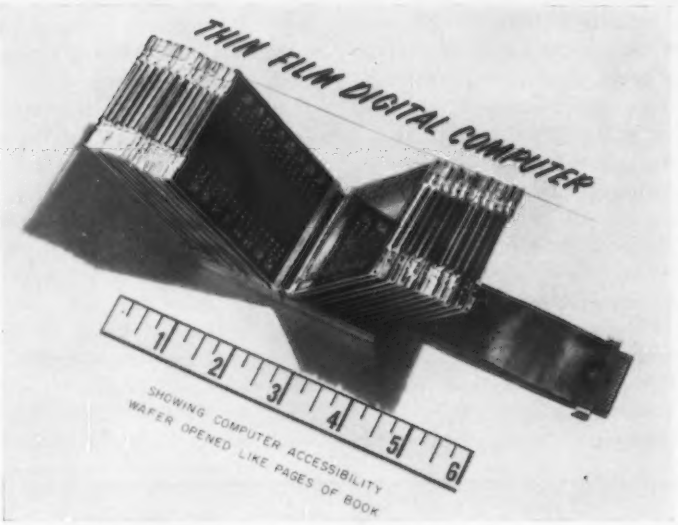
SYSTEM FUNCTION	EQUIPMENT*	OPERATIONAL REQUIREMENT/ADVANTAGE
Pre-flight checkout	C, D	Automatically performs pre-flight checkout of CEMS and other aircraft subsystems. Identifies failures for pre-flight maintenance.
Take-off monitor	C, D	Performs take-off computations prior to and during take-off run. Allows safe operation with maximum payload at all times and conditions.
Vertical speed-altitude scheduling	C	Provides automatic control of vertical profile during climb-out operations. Insures accurate adherence to optimum schedules for minimum fuel consumption with proper noise restrictions on profile.
Area (off-airway) navigation	C, D	Provides continuous area navigation automatically during entire flight. Removes restriction to airway or corridor navigation. Flight plan may be altered in flight by pilot.
Cruise control	C, D	Provides continuous command or control functions for maximum range, minimum cost, maximum endurance, or other selected criteria as desired.
In-flight system test and monitor	C, D	Performs systematic in-flight monitor of specific systems and parameters. Records pertinent statistical data, predicts and/or identifies failures for rapid preventative maintenance and/or repair.
Terminal area maneuvering (vertical and horizontal)	C, D	Provides capability for airborne insertion of desired or commanded approach pattern, in both horizontal and vertical planes. Allows area navigation and monitoring via navigation display, permits more flexible approach techniques, higher acceptance, shorter stack times.
Continuous position determination and display	C, D	Computer accepts information from several data sources, provides continuous position determination calculations. Navigation display provides continuous fix reporting information and orientation to geographical references regardless of weather conditions.
Automatic two-way (ground to air to ground) data link	C, D	Computer decodes ground to air data link commands and displays data on integrated navigation display. Computer also assembles messages automatically or through manual insertion, and transmits pertinent position and flight plan data to ground control center.
Automatic landing	C	Computer provides accurate gain scheduling, trajectory control automatic tie-in with throttle, autopilot for automatic landing systems. Adaptable to variety of inputs and control laws.

* C = Central Computer utilization.
D = Integrated Multi-purpose display.

▶ **CENTRAL ELECTRONIC MANAGEMENT SYSTEM** (CEMS) is proposed for supersonic transport by Hughes Aircraft Co. Navigations display console would give pilot continuous position data from digital computer. Layout shown was designed for subsonic aircraft.

◀ **NAVIGATION DISPLAY** unit of Mach 3 transport integrates optical and electronic information on the same screen to eliminate viewing parallax. Hughes suggests two-way data link with FAA stations be built into face of display.


PROJECTION LAMP AND REFLECTOR
FILM MAGAZINE
PARTIAL MECHANISM FOR SLEWING PROJECTION LENS IN X AND Y
8"
OPTICAL PROJECTION LENS
16"
HIGH VOLTAGE LEAD
6" DIA. DISPLAY SCREEN SHOWING 11 ELECTRONICALLY GENERATED SYMBOLS SUPERIMPOSED ON AN OPTICALLY PROJECTED MAP
DOOR FOR REMOVAL OF FILM MAGAZINE
ELECTRICAL CODE PICKUP FROM FILM
OFFSET ELECTRON GUN AND YOKE
OFFSET CATHODE RAY TUBE (CRT)



THIN FILM DEVICES will blossom in next few years. Hughes' proposed use of such components in outgrowth of CEMS (Central Electronic Management System) to save weight, increase reliability.

Preflight—The present military version of CEMS uses a computer-display team as a preflight check-out device. Instructional charts and check lists are projected on a display screen from a film magazine. These charts define the proper combinations of control settings and systems responses. The CEMS computer can use its stored program for preflight check to evaluate, radar, communications, navigation devices, air data computer, etc. Checkout time has been reduced from eight hours to five minutes on some aircraft.

Automatic Navigation—Climbs, descents, and enroute operations should lend themselves to automation and optimization in the supersonic transport.

Military systems again provide the basic inputs for airline equipment in this case. The military has used the digital computer for both the cruising and terminal portions of a flight.

The supersonic transport will probably use an inertial system to meet its primary navigation needs. An automatic true-north seeking gyro will align the platform on the ground. Doppler damping or stellar monitoring could be provided, but in all probability would not be necessary for average flight duration of two hours. Accuracy will degrade about 1 mile for every hour of flight time without compensation.

The digital computer would provide constant position information. This information would be displayed on the type of unit now gaining wide acceptance in the military.

A flight plan and other data could be printed on a punched card. Copies of the card would be fed to air traffic stations along the route. The master copy could be inserted into a central airborne-flight-management-computer. The computer would also accept inputs from the inertial platform. The pilot would get parameter data on a display unit showing recommended speed, climb angle, and altitude to abide with his flight plan. FAA reporting stations would be automatically tuned in, and position reports would be delivered automatically. In an emergency the display console would show time and distance to the best alternate destination.

Many of these features are incorporated in B-58, F-105, A3J, F4H, etc. Others are extensions of the state-of-the-art.

Anticollision Devices—The digital computer is finding its way into airborne devices for avoiding other aircraft. FAA classifies these airborne devices in two categories:

- Collision Avoidance Systems (CAS). They detect and evaluate the collision threat, then compute and display the best escape maneuver to the pilot.
- Pilot Warning Instruments (PWI). They assist the pilot in detecting and locating other aircraft, but leave the evaluation of the escape maneuver to the pilot.

The largest development effort to date is with CAS, because data on pilot capability is lacking and/or inconsistent. For the supersonic transport it is the only system that can be effective.

Tests are already being conducted with modified rendezvous equipment used by B-52 and tanker aircraft. An airborne computer has been integrated into the system.

FAA, however, feels "no system . . . is sufficiently developed to warrant a decision for implementation. It will take at least three years effort to gather sufficient data for such a decision."

Malfunction Warning — The data processing ability of digital computers makes them a natural to monitor systems in flight. Several companies have suggested that a separate small computer be used in SST to detect impending failures. This would not only give the pilot time to react, but would cut down expensive maintenance time on secondary items. Such a system could hardly be retrofit into the aircraft. The sensors and interface with the computer would have to be designed into the aircraft at the outset.

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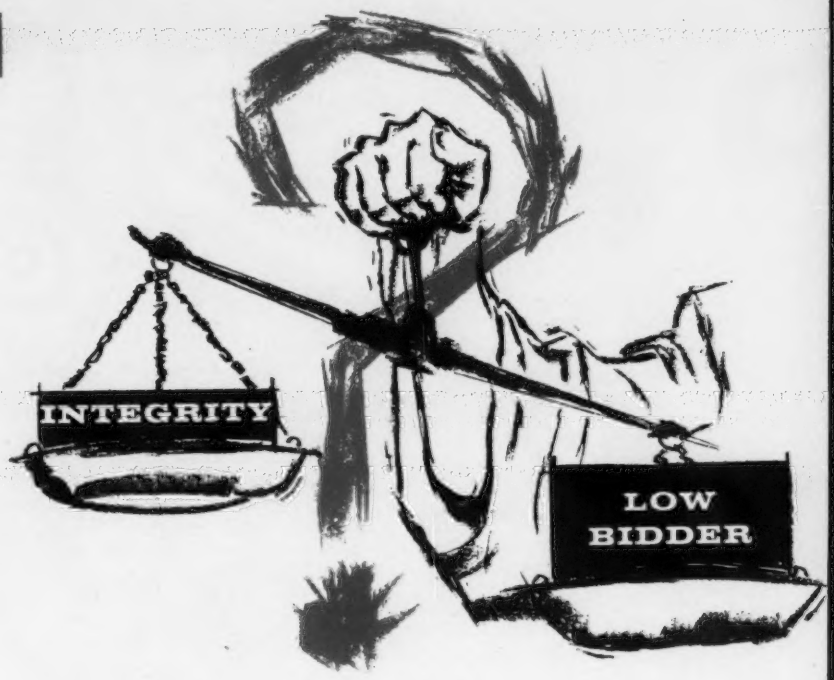
STATE YOUR CASE

Integrity vs Low Bidder



by Denham S. Scott
Assistant to the President,
The Garrett Corp.

Availability and reliability of weapon systems are of vital importance to the nation. Weapon system mission-readiness depends on replenishment of bits and pieces for the spare-parts inventory, where we reach the root of the current controversy on alternate sources. This is the domain of the Armed Services Procurement Regulations (ASPR).

In discussing ASPR's and specifications there is danger in obscuring the basic realities of the problem—the performance of the equipment and the safety of the men who man and maintain it.

We all agree that there can be no compromise with safety, but we must find a way to eliminate the risks inherent in the existing questionable procurement-practices. The present impasse can only be broken by a willingness by both parties to compromise. Industry must be prepared to make concessions on competitive procurement, but the services will have to adopt a stiffer attitude against the contamination of our spare-parts-logistics system.

Prior to World War II, the traditional pattern in the aircraft industry was clear-cut: The Army Air Force and the Bureau of Aeronautics announced in advance their planned needs for the different types of aircraft. Performance specifications were presented upon which interested companies undertook to risk their private capital. Resultant prototypes were then competitively evaluated and, later, a fixed-price contract was negotiated with the winner. Since the competing contractors were completely financing these ventures with their own or their stockholder's money, it was obvious that each owned the design rights to their entries. That pattern, once clear and simple, has gradually faded into the past. The process obviously was competitive, but fair and equitable to all, and all who chose to compete knew the rules of the game.

Certainly, the government is spending millions of tax dollars for research and development and is therefore entitled to the free use, for governmental purposes, of the new knowledge gained in performance of these contracts. Private industry is also spending millions of private and stock-holder's dollars to further the national race for technical supremacy.

Regardless of who finances the research and development work, the end result is up-to-date "know how," often in the form of manufacturing drawings, novel processes, techniques, etc. This "know how" or these "trade secrets" represent very valuable property. Exclusive possession of superior "know how" gives a tremendous competitive advantage to any company operating under our free-enterprise system. This system derives its driving power and its success from competition. Therefore, the matter of ownership, including as it does the right to withhold or restrict the use of this data, becomes a deadly-serious matter to the design manufacturer.

In spite of a welter of confusion certain facts emerge with reasonable clarity:

- Industry no longer can claim right and title to everything.
- Government cannot claim the right and title to everything.
- The property at stake is very valuable, therefore, the inherent American tradition for fair play, demands a prompt solution that is fair and equitable to both parties.
- There are black (100 per cent government financed) and white (100 per cent privately financed) areas, and these can and should be sorted out and should be easily resolved.
- Gray areas represent the big problem, and if injustices are to be avoided, they must be negotiated on a case-by-case basis at the time of procurement. Present attempt to solve them with a broad brush treatment has proved to be impractical and inequitable.
- Present Department of Defense approach, is to insist in all cases on the submittal of every conceivable vestige of a contractor's data, per MIL-D-70327. At the same time, in many cases DOD arbitrarily buldgeons the "unlimited right clause" into the prime contract as being applicable equally to the prime and to all tiers of participating vendors or subcontractors. This total disregard to property rights, is contrary to traditional American principles of fair play.
- There can be no compromise with safety.
- The government cannot justify its demand for either complete data or unlimited rights in many of the cases where they are now seeking both.
- A contractor's good reputation is an invaluable asset closely associated with the performance of his products. Such contractors can be seriously and unjustly injured if unauthorized or bogus parts are permitted to contaminate the supply system. This issue involves aspects of safety, reliability and morality.

Some Proposed Answers—The above problem could be substantially reduced, and the government saved millions of dollars annually. This can be done through a sincere and determined effort, by Department of Defense, to implement that part of the present ASPR IX Part 2 policy statement which reads as follows:

"It is the policy of the Department of Defense to encourage inventiveness and to provide incentive, therefore, by honoring the 'proprietary data' resulting from private developments and hence to limit demands for data to that which is essential for government purposes. The activity responsible for initiating a purchase request, after consultation with the procurement activity whenever feasible, will carefully determine the use contemplated for the data to be acquired and will specify only such data as is determined to be necessary to satisfy such use."

The laudable policy expressed here has never found its way into our contracts. It has been completely negated by the practice of incorporating such specifications as MIL-D-70327 into all DOD contracts.

It is a fact that the DOD annually spends many millions of dollars to obtain and maintain millions of contractors' drawings, most of which are never used by them. Reason given is that in any specific case a need could arise. I believe they are following the easiest path by obtaining 100 per cent data to assure the availability of less than 10 per cent.

I believe that Mr. McNamara and his new team are genuinely concerned with the need to reduce costs, and that they will insist on convincing answers to such questions as "Why does DOD need microfilm copies of the details of a nonreparable vendor item? Or, if single copies of paper prints marked for the purpose can satisfy the provisioning (or the cataloging) functions, why must we also pay for microfilm?"

The mood to ask these and many more questions is here now. We should insist on helping them to find the best answers. We will never have a better opportunity. In cases where government has clearly paid for everything (previously alluded to as black) regardless of whether the contract calls for Class 1 (government format) or Class 2 (contractor's format) the government is entitled to unlimited rights, for governmental purposes only, of all the resultant drawings. Unless classified for security purposes, the contractor should be left free to develop any commercial possibilities. As for the case where the contractor has clearly borne the whole costs of developing the item (the white area), the design and all drawings should belong to the contractor. This Class 2 package should be for sale only on the owner's terms.

Now let us tackle the really-controversial gray-area where contractor and government funds have become hopelessly mixed, for instance, by the acceptance of a product-improvement contract following a company-financed project. In these instances the only solution lies in a case-by-case decision based on facts. In all cases the government has a right to the free use, for governmental purposes, of part which resulted from expenditure of government funds. However, the contractor should have complete commercial rights in return for his contribution, which included supplying the accrual of his investment in facilities, skills, and a wealth of specialized background of technical knowledge. The government has no business competing in the commercial market, and therefore, no interest in commercial rights; whereas, the contractor is in business to capitalize on these investments. Such mixed data could bear proprietary legends or placards prohibiting their unauthorized use except by the government for governmental purposes. The privately developed portion of the data belongs to the contractor, and the future manufacturing rights including future government contracting are presumably v a l u a b l e property; therefore, the government should carefully determine the use contemplated for the data and specify

only such data and rights as actually required for a clear governmental need. All requirements for data should be a separate contractual item with the needs and the rights clearly out in the open. Thus, each party can negotiate intelligently. In most cases the government should not ask for unlimited rights to drawings developed at private expense. It should instead be willing to agree that such data as are actually required for miscellaneous support functions will not be used for competitive procurement purposes.

Present policy and practices have produced a tragic state of disharmony, wherein Small Business, Big Business, and the Procuring Services negotiate with each other in an atmosphere of distrust. Also who knows how many of our aborted missile firings, and unexplainable aircraft tragedies are the result of pollution of stock due to bogus parts received from the low bidder? Integrity and "low bidder" are by no means synonymous. Often small but important advances in material composition, treatments, and techniques, add up to the vital difference between reliability and failure. These improvements cannot always be shown on drawings. For instance, there is no way to spell out all of the applicable requirements of MIL-Q-9858 on our drawings. Thus, the low bidder in a typical competitive bid is not necessarily bidding on the same thing as the designer, and the millions of dollars spent for safety and reliability are sometimes sacrificed on the altar of false economy.

The typical contracting officer, or buyer for the government, is a patriotic, conscientious soul, but today he sits on a "hot seat" in which he must conform to many regulations and political pressures, some wise, and some not too wise. He must increase the percentage awarded to Small Business, depressed areas, by advertised bids, etc., but above all he is under heavy pressure to seek the lowest bidder in competitive procurement. He is just as anxious as we are to find the answer to the question, "Where can we safely compromise?"

The solution, I believe, lies in a closer study by industry and the contracting officers of the possibilities included in ASPR 1-313, from which I quote excerpts:

"(a) Parts for military equipment, to be used for replenishment of stock, repair, or replacement, must be procured so as to assure the requisite safe, dependable, and effective operation of the equipment."

"Where it is feasible to do so without impairing this assurance, parts should be procured on a competitive basis, as in the kind of cases in (b) below."

"However, where this assurance can be had only if the parts are procured from the original manufacturer of the equipment, or this supplier, the procurement should be restricted accordingly, as in the kind of cases described in (c) below."

"(c) Parts not within the scope of (b) above generally should be procured (either directly, or indirectly) only from sources that have satisfactorily manufactured or furnished such parts in the past, unless fully adequate data (including necessary proprietary data) test results, and quality assurance procedures are available (or can reasonably be made available in keeping with the policies in ASPR Section IX, Part 2) to assure the requisite reliability and interchangeability of the parts, and procurement on a competitive basis would be consistent with the assurance, described in (a) above. In assessing this assurance, the nature and function of the equipment for which the part is needed should be considered. To illustrate, acceptable tolerances for a commercial television part may be far less stringent than those for a comparable military radar part, permitting competitive procurement of the former but not of the latter. The exacting performance requirements of specially-designed military equipment generally demand that parts be closely controlled and have proven capabilities of precise integration with the system in which they operate, to a degree that precludes the use of even "apparently identical parts from new sources, since the functioning of the whole may depend on latent characteristics of each part which are not definitely known."

I submit, that regardless of whose dollars paid for what, a design manufacturer has the right to protect his reputation from the effects of the infiltration of unqualified parts into his nameplated products.

In these mixed situations, prime contractors should take a careful look at every item on their Procurement Parts Breakdowns in conjunction with ASPR 1-313 and deliberately concede that many non-critical items can be safely procured from competitive sources—even set aside for Small Business. On the other hand, if for reasons of safety, reliability, and critical applications, the designer insists on proven sources, then such drawings should be coded with assurance that such codes will be honored. Such determination could become a part of future Provisioning conferences, at which time presumably there is expert representation of the design manufacturer and the procuring service.

We suggest that when mutual agreement has been reached a legend essentially as follows be placed on drawings for critical parts or applications:

"Critical Part. Reliable performance of the end product depends on the precision and integrity of this selected critical part. The ABC Company recommends that procurement be restricted to original manufacturer in order to comply with the requirements of ASPR 1-313 in effect on (current date)."

If the government would accept this plan, and assure us that such notices would be honored, most of us in the aerospace industries for our part, would be willing to furnish unemasculated drawings. However, if some such plan is not acceptable to the government, then I believe industry will be completely justified in insisting that new part numbers, including new Federal Stock Numbers be assigned to bogus parts, and that after repair and overhaul functions during which these ersatz parts were introduced, that a placard of some kind be placed adjacent to the contractor's nameplate, relieving him of responsibility for future performance. ✦

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Judging equitably the quality of suppliers is a complex task for prime contractors. Having recognized this, the Material Section of the Norair Div., Northrop Corp., has established its supplier rating program.

The simple arithmetic of counting rejected parts often fails to provide a true index of workmanship. A much broader view is required in this assessment, including:

- A proper analysis of the difficulty of the work undertaken.
- The interpretation of specifications imposed.
- Extent of corrective action exerted by the supplier—both before and after the fact.

These factors are certainly considered in granting him his "day in court" before a rating judgment is passed.

Norair does not claim that this rating system provides the ideal measure of supplier's ability. Obviously no foolproof approach has yet been devised to handle the many factors or the heavy volume involved in modern-day sub-contracting.

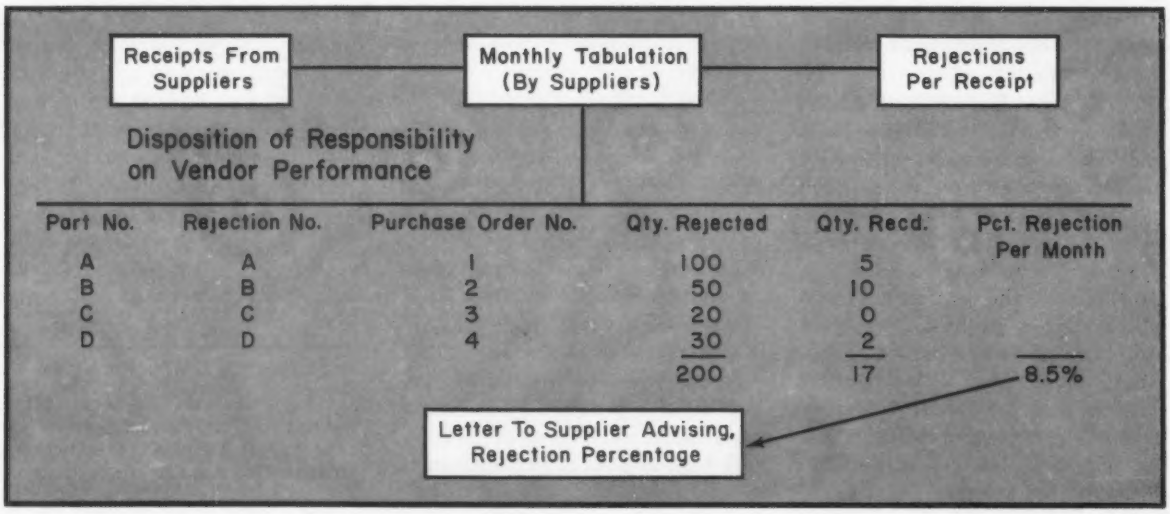
It is claimed, however, that the Quality Rating Program, outlined briefly here, provides means of gauging supplier quality control effort which goes beyond the usual run-of-the-mill statistical analysis.

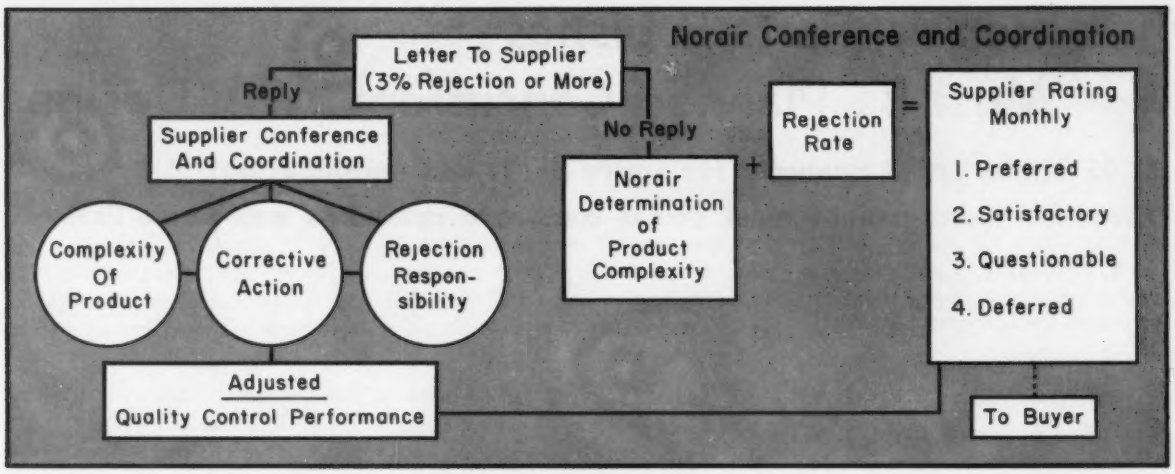
The main objectives of this program are:

(1) Monthly written notification to all suppliers, regardless of rejection rate, as to their current quality performance.

(2) Determining and relating the complexity of the product supplied to the margin of error.

(3) Encouraging suppliers to participate in the mechanics of





establishing their own quality rating.

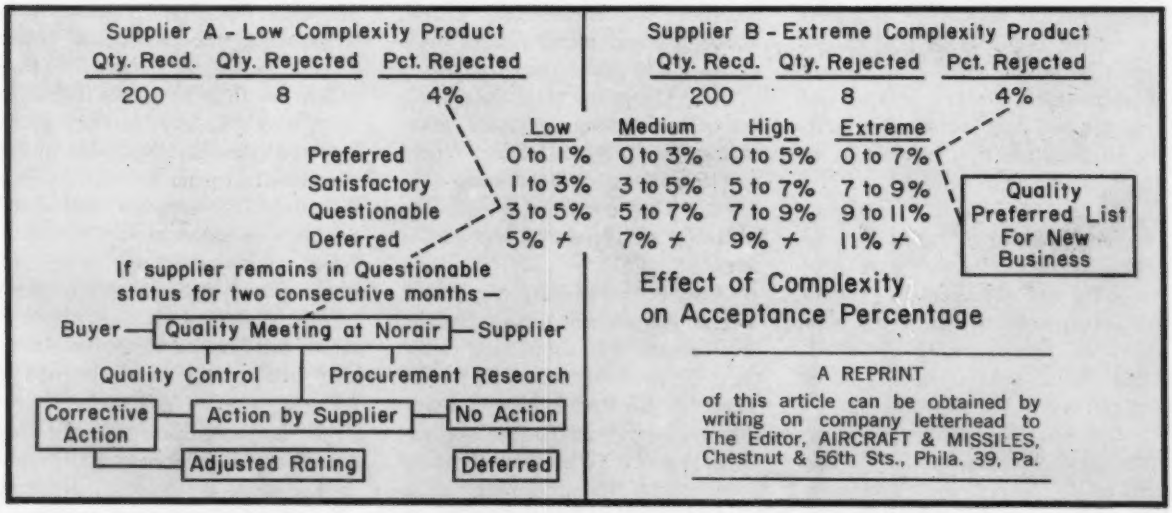
The charts which follow explain progressively the basic procedure used in making Quality Rating determinations. In the interest of simplicity, much of the detail has been omitted.

One point should be stressed. Although monthly reports are furnished to the buyers for their guidance and information, an individual rating and classification is established only on the basis of at least three months' experience. "Questionable" and "Deferred" categories cannot be justly determined on one receipt, or one order, or even one month's activity, with or without supplier negotiation.

Primary purpose of this program is not to create a selective and discriminatory list of suppliers, but to assist all sources in improving quality and maintaining equal opportunity to receive future business.

DETERMINATION OF SUPPLIER CLASSIFICATION

Product Classification	Product (Typical)	Preferred	Satisfactory	Questionable	Deferred
Low Complexity	Standard Parts, Raw Stock, Commercial and Proprietary	0 to 1%	1 to 3%	3 to 5%	5%+
Medium Complexity	Norair Design Functional Components, Special Parts, Average Machine Parts	0 to 3%	3 to 5%	5 to 7%	7%+
High Complexity	Machine Parts with Numerous Operations	0 to 5%	5 to 7%	7 to 9%	9%+
Extreme Complexity	Vendor design functional Components, complex machine parts, state of the art and development products	0 to 7%	7 to 9%	9 to 11%	11%+



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Repair–Parts Logistics Must Be Planned Concurrent With Design

$2.05 billion spent annually for spare parts and modification; Technical management must stress accurate drawings and parts lists;

by R. K. Stevens, Administrator, Products Service-Logistics Unit, Ordnance Dept., General Electric

Repair-parts support is the life blood of our weapon system complex.

Armed Services plan to spend a total of $2.05 billion for modifications and spare parts for fiscal '62. This breaks down as follows: Air Force, $875 million for spares, and $672 million for modifications; Army, $33.2 million for spares; Navy, $421 million for spares, and $50 million for modernization.

Without repair-parts support, equipment will be mission-ready only until the first part failure or breakdown. Any operation of the equipment thereafter will be on a degraded performance level. Thus, a modern version of the "missing nail" parable may be derived—that for the lack of a ten-cent resistor a multi-million dollar weapon system could be rendered inoperative.

Hence, the Armed Services require that all equipment procured by or for them (with few exceptions) be so designed that normal maintenance and repair policies and routines will enable the using facility to maintain that equipment in ready operating condition.

To this end, the cognizant government procuring branch has established specific repair-part provisioning and procurement policies and procedures to which the suppliers are contractually obligated. Until the supplier complies, he is not entitled to full payment.

Just what has all this got to do with systems management? The answer . . . everything. The parts lists, bills of material and all drawings developed and issued are basic data governing all provisioning and any subsequent follow-on support effort. Thus, if that "ten-cent" resistor is not listed, it is not acted on and the support program is not complete.

What Provisioning is? — Basically, this is the process by which the government, in conjunction with, and assisted by the manufacturer, determines the equipment components required to support a new weapon or equipment for a specific time period.

Who does the Provisioning?— The provisioning team usually comprises representation from these areas:

(A) The prime government user (Army, Air Force, Navy) including branch or bureau specialists in: supply management, procurement, technical or engineering liaison, cataloging and identification, preservation and packaging.

(B) The prime contractor: project engineer, design engineer, manufacturing, product service (field representatives), sales, finance.

(C) The contributing subcontractor(s) and vendor(s) representatives.

Why is Provisioning Necessary? —The government using activity must insure that supporting repair parts are available AT THE SAME TIME as the end item to provide the necessary ready-state operational support. To accomplish parts-provisioning, the following areas must be defined and fully clarified:

- Source(s) of supply.
- True number and nomenclature
- Manufacturing lead-time or procurement cycle
- Estimated or budgetary prices
- Availability of like parts in the system
- Life expectancy of the part(s) (Reliability)
- Parts population i. e., how many times is the part used in the equipment
- Special handling and environmental requirements due to the design, material or operational characteristics
- Interchangeability
- Special tools and/or test equipment requirements
- Maintenance philosophy

Presentation of Facts — With few exceptions, this information is available to the provisioning team in the basic documentation submitted for their use. This is true in cases where the information is properly and completely included in the prescribed formats as listed in specifications (government and commercial) included within the contract. Any omission, error, or unauthorized deviation from these contractual documentation requirements will impede the provisioning, and timely support, of the equipment or weapon system.

It is recognized that the required technical documentation for provisioning, is complex. It must

also be recognized as being necessary, due to the extreme complexities of governmental supply and support systems, the large and complex variety of items in the supply systems, and the gigantic range and depth of items and equipments in the systems. Each line item (part) requires full and equal review, documentation, listing, management, cataloging, and surveillance from the time of procurement until the part has been obsoleted, by design change or improvement, and is ultimately purged from the supply system.

It is therefore a strict charge by the government to, and acceptance by, the supplier to maintain a true record of the part throughout its service life. Any failure to keep such a record, or not notify the using activity of changes to the part, will result in costly delays to all concerned.

To appreciate and understand how important each contribution is and why it must be made, let's review and amplify the areas delineated above.

First and most important we must have a true and complete parts list (PL) supplemented by a drawing of every item listed.

This data will give such basic information as: part number, nomenclature, next higher assembly, material, source(s) of supply, all markings or special considerations, dimensions, unit weight, revisions.

The unit weight is a specific requirement of the preservation and packaging branch. This data should be included at the outset for planning and costing estimates relative to shipping and storage of the repair parts.

Manufacturing lead-time must be known in order to program and plan the ordering cycle for the part. This information is of particular importance where highly complex items are concerned, which usually require long procurement-time.

Another critical factor is pricing. Although prices may be rough estimates, such data are needed for funding and budget estimating, to establish the levels of support.

Parts population and availability of like parts in the support system are additional factors considered in provisioning. Parts population directly affects the depth to which support will be accomplished. In this regard, the true manufacturer's part number identification is very important, particularly when there are several vendors supplying parts, or assemblies, to the end item build-up. If care is not exercised in part number identification and listing, it is almost impossible to detect malnumbering, and thus lose a true record of parts population.

The availability of like parts in the system also governs the provisioning of support parts. If alternate parts are called out, it is possible for the provisioning team to research such data and establish the quantitative buying policy for a part. Failure to indicate this information can result in possible overstocking of items at a needless cost to the government and ultimately to the tax payer.

Life considerations also generate questions from the provisioning team to establish reasons for "sparing" a part. These are:

- How essential is this part to the operation of the equipment?
- How long will this part last?
- What happens to the equipment if this part fails?
- How long will it take to repair this part?
- Can we substitute something else for this part?
- Are there any special tools required?
- How often do you think this part will fail?

Most of these questions are already answered in the designing of the original equipment. At times, the engineer can only give his opinion or estimate as to what will occur, but even these opinions will aid in properly supporting the end item or weapon system. It is fact that the actions of a provisioning team have resulted in the review and redesign of end item equipment. This is more likely to happen at re-provisioning meetings when more actual usage data is available.

Although the armed services will determine and advise the methods for preservation, packaging and packing the repair parts, the contractors are obliged to advise them of items that will require special attention in packaging and shipping. Needs for special environment protection, extra physical protection, and items subject to deterioration with time or inactivity should be pointed out as the parts are provisioned.

Interchangeability is one of the most complex, costly and often confusing aspects of repair-parts provisioning. When the end item is first designed, interchangeability is usually non-entity in that the equipment is either made up of common hardware items, standard catalogue items, or all specially-designed parts. But, once design improvements or changes are introduced, the problems associated with interchangeability can, and do, become very complex. Such information establishes whether the superseded and superseding parts are truly interchangeable.

The introduction date must be clearly indicated in all documentation. This date should be established only after due review of:

- Need for the change.
- Status of present part in production.
- Effect on parts in the field, in supply system.
- Will parts be pro-rated or will the change be made to all units shipped and in-building?
- Who will pay for the retrofit?
- How will change affect operation of equipment?
- Is it economically-sound to make the change?
- What technical publications will have to be changed? When can this be done?
- When will the superseding part be available?
- Have the new part numbers been assigned and added to the documentation affected?

Special tools and special test equipment comprise all special devices required to assemble, disassemble, maintain and check the

Faulty records cause costly delays and needless paper shuffling

parts. These do not include standard tools and equipments that are readily available in the open market as commercial items. There is usually a stipulation in the basic design specifications to the effect that the equipment be so designed as to minimize the need for special tools or special test equipments. It is also required that all such special tools and tests equipment necessary to maintain the end item should be properly documented, and provisioned.

It is the engineer's responsibility to review these special tools to ascertain their applicability, need and design, and then have the proper drawings, parts list, etc., prepared and issued. Quite often the need for special tooling is not discovered until the equipment is in the field. Regardless of when, where, or how this need arises, the above review and documentation process must be followed. It will thus be possible to apprise the customer of the tooling needs to provide the necessary support. As for maintenance aspects, at the outset of the program the Armed Services will indicate the design objectives and the maintenance allowed and required with the weapon system or equipment.

Post-Provisioning Action—This is the same for both production and R&D programs. The customer will review the decisions and quantities of repair parts provisioned, and then issue contractor procurement authorization. This sounds simple and straight forward, but let's delve into some of the major activity required to issue the procurement list. Each part that is provisioned as a required support repair part must be catalogued and identified by a specific Federal Stock Number (FSN). If all the data and documentation is not complete and correct, the FSN cannot be issued until clarification is received. Here it is important to note that until a part is identified by a FSN, it cannot be shipped into the supply system. This edict is tempered in situations, and only by a waiver from the customer can such "unlisted" parts be shipped. These few items so shipped are closely followed and clarification is expedited to ensure prompt issuance of FSN's.

Concurrent with the request for an FSN, data and documentation are furnished the packaging branch for their use in establishing the method of pack for each item. Here is where the notification, by the contractor, for special handling is considered to ensure that proper protection will be called out in the packaging instructions. Again, any omission of information will be reflected in possible mal-packaging instructions which will result in damaged unuseable material that could impair the effectiveness of the weapon system or equipment. On receipt of the processed data from the several support branches, the supply management facility will establish and issue procurement authorization to the contractor. He, in turn, processes the information and places orders for the items released. It would have been reassuring at this point to report that the vendors manufacture the items and ship on schedule; all material is accumulated and dispersed in accordance with the customer's direction; and all parts arrived intact and are readily available as needed. This could be true except for one thing—design changes.

Actually, even this nemesis poses no great problems—provided the supporting data and documentation is complete, correct and promptly dispatched. The processing of design changes is much like that for initial parts-provisioning. Now the differences in processing require more adroitness on the part of the engineer and draftsman to ensure that the change is clearly depicted and documented.

It must be remembered that a change usually affects two parts—the superseded and the superseding. Disposition must be given to the superseded part. It is the engineer's responsibility to properly investigate and establish the disposition. This requirement cannot be overlooked, or shirked. Until disposition is declared, the documentation is not complete, the change cannot be processed to the customer, and thus, in fact, we are not supporting the equipment.

Never Ending Job—The acid test for all parts-provisioning, documenting, procuring and ultimate shipment comes when the part is needed to replace one that is defective. If we all have fully subscribed to the established requirements, it is then a matter of routine to effect the replacement, and restore the equipment to an operational state.

Despite the restoration of the equipment to its intended operable condition, the job is not done. There must be a feed-back, relative to the failure or failure rate and such supplementary data, to the design group for evaluation and for future design considerations. By using existing reporting practices, implementing new routines, where necessary, the data is transmitted to the cognizant personnel for their government and action.

The important facts to remember—and practice—are that all the data and documentation prepared and processed must be accurate, completely descriptive and promptly dispatched.

In the ever accelerating technological race, time is our greatest enemy.

Let's not sabotage our gains by generating confusion in the form of mis-information and/or unclear documentation. Clarification takes time—the shortest commodity in supply.

◆

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ELECTRONIC PROGRESS

Skybolt Checkout Automated

Universal-tester concept aimed to stretch Air Force's AGE dollar; Bendix adapts programmer-comparator to ALBM ground testing; Modular design provides for growth factor and versatility

by S. Peter Kaprielyan

Variety, complexity, short lead-time and early obsolescence mark today's weapons-system arsenal. The need for concurrent development and production has ramified the tasks of weapons-systems managers. These problems expand further in the tier of checkout-equipment producers. For, makers of checkout systems often must anticipate the needs of weapons-systems designers before the weapon concept has jelled.

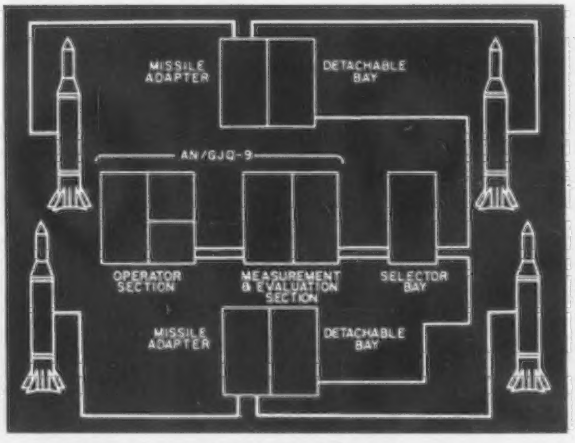
Repeat grappling with this problem both by industry and Air Force gave birth to specification MIL-P-26664A (USAF). Tenets of this specification stress universality and versatility for future checkout equipment, with automatic operation viewed only from practical aspects.

The Air Force's Douglas-built Skybolt will be the first missile to reflect this philosophy, namely the Checkout Sequence Programming Set, Air Force Type AN/GJQ-9. It is designed and built by Bendix Support Equipment, Eclipse-Pioneer Div., The Bendix Corporation, and has been ordered by the Air Force in production quantities.

Design Philosophy — Design of checkout systems evolves basically from two types of functions: (a) common-denominator type functions which are independent of systems to be tested; (b) functions peculiar to the systems to be tested. With this point of departure, the circuitry and components for the independent functions are housed in a cabinet group called the programmer-comparator (PC), while the equipment governing the functions dependent on system characteristics are grouped in "adapters."

This concept is the key feature of the Q-9, and provides for long-range improvements in weapons-systems and automatic testing techniques.

When Skybolt joins the ranks of operational missiles the Q-9 tester will be used to check out the tactical readiness of the missile at all levels of maintenance. Marriage of PC concept to special-purpose adapters extends the application of the Q-9 also to space probes, monitoring of



▲ **TYPICAL TEST ARRAY** depicts four stations for the checkout of missiles one-at-a-time.

◀ **AN/GJQ-9 TESTER** will check mission-readiness of Skybolt missiles shown under B-52 wing.

Tester multiplexed for many adapters; Control capacity expanded to 3000 channels

atomic-energy generation, and to general industrial processing. Automatic feature of Q-9 allows semi-skilled personnel to control and assess complex mechanical, electro-mechanical or electronic equipment on a GO-NO-GO basis.

How Q-9 Operates—The basic circuitry and hardware of the Q-9 are assembled into 18 subsections within five cabinets. Punched tape is used to store data for programming, measuring, and evaluating the system under test.

Program control elements receive inputs from a photoelectric, scanning-type tape reader. Photo diodes in reader convert the eight-hole pattern into electric signals. In the "normal" automatic or "program-search" mode the information is scanned at 150 lines/sec. Tape reader runs at 800 lines/sec in a slewing and rewind mode. The program-control capability allows storing of a test number and automatically searches for the desired test number on tape; upon the "find," the system reverts to normal routine.

Although normal mode of operation is automatic, test set can also be operated manually to run or re-run specific check points if needed.

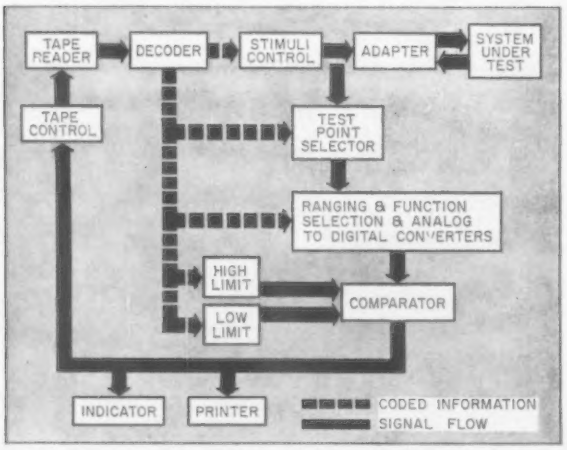
Through a binary coded network, parallel comparison is made of each test point measurement value. Comparison with both the high and low tolerance limits provides the decision as a GO or NO-GO output signal. Continuous data-recording is provided by both visual and printed readout systems, throughout tester operation.

Printer translates binary coded data into decimal form, and prints the following data in single-line on pressure-sensitive paper: test number; value and polarity of upper limit, answer, and lower limit; range and type of measurement; GO, NO-GO indication.

Self-Checking—Tester also features self-checking provisions for fault isolation. Each switching action decoded from tape is compared, by feedback, with the encoded information. Agreement allows tape to advance; disagreement stops it. An auto-check GO or NO-GO is then given as required. A parity circuit detects tape error due to wear or misuse. A self-check tape system automatically verifies that all logic switching, input and output circuits are working correctly, and that all measurement units are operating within required accuracies.

Program Control Capacity—Programming set is capable of selecting up to 200 test points for measurement and includes 100 channels for weapon-system stimuli control. Provisions have been made for an additional 200-test-point selector and one additional 100-channel stimuli control unit. The control and selection logic capacity is capable of selecting a maximum of 2,000 test points for measurement and 300 stimuli control channels.

Through an additional bay of equipment, the Q-9 is effectively multiplexed for use with many adapters. With this addition, control capacity is multiplied by a fac-



SIMPLIFIED BLOCK DIAGRAM shown above traces flow of coded information and signals. In operation, AN/GJQ-9 is connected through adapter(s) to system under test. On command from taped instructions, tester routes stimuli control signals from stimuli (signal) generators in adapter. Stimuli from adapter go to system being tested.

AN/GJQ-9
PROGRAMMER-COMPARATOR
MEASUREMENT CAPABILITIES

MEASUREMENT	CAPABILITIES
Display	3-Digit (0.999 to 99.9V)
DC Voltage	
Ranges	1, 10, 100, 1000 V
Accuracy	± 0.1% Range ± 1 Digit
Conversion and Setting Time	Approximately 300 Microsec.
AC Voltage	
Ranges	1, 10, 100, 1000 V
Accuracy	1.0% Range ± 1 Digit 60 CPS to 5 KC 3.0% Range ± 1 Digit 5 KC to 10 KC
Resistance	
Ranges	100, 1000, 10,000, 100,000, 1,000,000 Ohms
Accuracy	± 1.0% to 100,000; ± 3.0% to 1,000,000
Time Intervals	0.1 Millisec to 10,000 Sec
Frequency	0.1 CPS to 1.0 MC
Voltage Ratio	
AC and DC	1, 10, 100, 500
Accuracy	0.1% of Range ± 1 Digit DC 1.0% of Range ± 1 Digit 60 CPS to 5 KC 3.0% of Range ± 1 Digit 5 KC to 10 KC
Phase	In-phase and Quadrature Components

tor of 10; that is, 3000 stimuli control channels.

Presently, the tester is being supplied in transportable bays, primarily for permanent installations. Modular construction, however, makes this equipment packagable in mobile units for field use. Tester is designed to operate in environmental conditions from —20° to 55° C. Power requirements are 115v, 50 or 60 cyc, single-phase, or 115/200v, 400 cyc, 3-phase, 4-wire.

Typical Application—A typical test arrangement for a complete missile system is shown in schematic form in Fig. 1. Depicted are four separate test stations, and it's assumed that one missile will be tested at a time. This array shows the Q-9 in three basic sections:

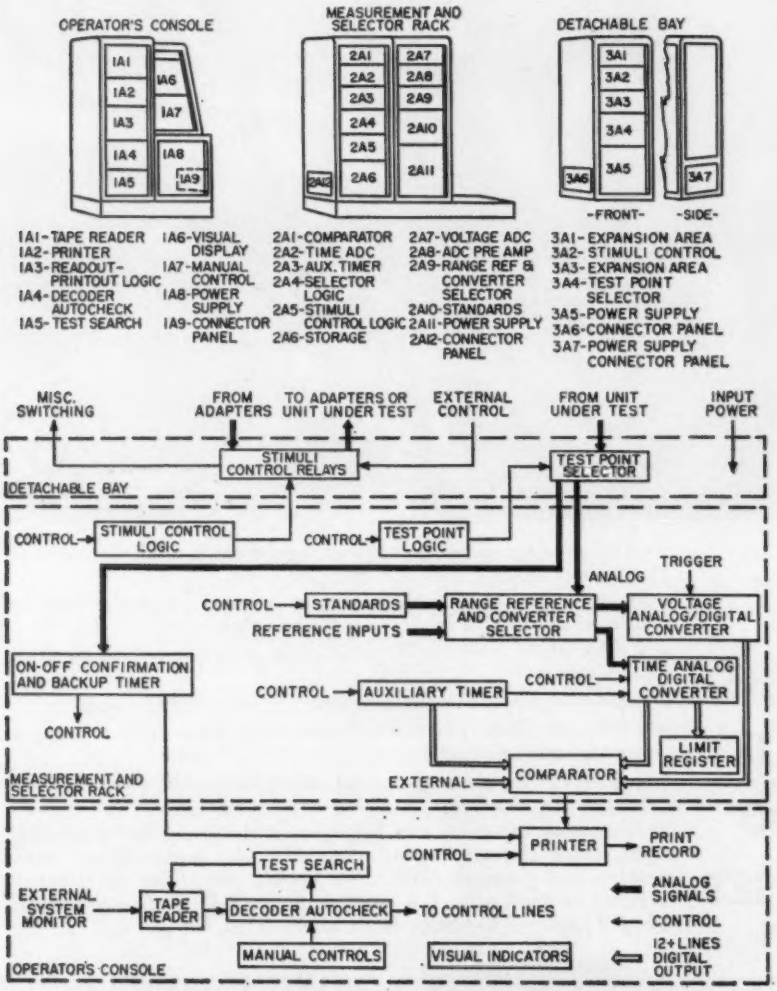
- A two-bay operator's console containing tape reader, printer, visual display, controls, and decoding circuits.
- A two-bay measurement and evaluation section, containing comparison circuitry, self-test standards, and decoding control for selecting test points and stimuli channels.
- A detachable bay including the hard switching (crossbar for test point and relays for stimuli selection) and the basic power supply.

Assuming that program control needs are beyond the 300 stimuli control channels of the expanded tester, a selector bay is inserted between the measurement-evaluation section and the detachable bay. This selector bay contains switching devices, a power supply, and some isolation circuitry to simplify connection of pulse information lines from the tester to the adapters. The switching devices operate by program codes from tester in a manner similar to operation of detachable bay. However, any one of the 2000 test points and 3000 stimuli channels now can be selected through 10 channels of the selector bay. As stated above, this increases the control capacity for stimuli by a multiple of 10, with the following advantages:

- Number of control lines for any group of test points or stimuli channel is considerably less than the actual number of hard switching points involved. Therefore, the number of wires from Q-9 to adapter is reduced.
- Control lines handle sizable, digital-type signals. This type of transmission is less susceptible to problems associated with long cables due to "noise," attenuation, and "cross talk" than are low-level analog and high-frequency test leads.
- Actual wires attached to points of the item under test are minimized in length by the proximity of hard switching to adapters.
- Selector bay may have the control lines for up to 10 adapters attached and left permanently in place. Cable handling is thereby reduced together with possibility of damage and human errors. Since the Q-9 is directed to the appropriate adapter by tape commands, only the cables to connect the adapter to the item under test need handling.

Aside from these operational advantages, the multiple use of standardized hardware (test-point crossbar switch assemblies and stimuli control relay assemblies) is attractive from economical and logistical aspects.

✦



BASIC CIRCUITRY of AN/GJQ-9 tester is housed in five cabinets, outlined above, with major subdivisions oriented functionally.

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AIRCRAFT & MISSILES 1961 MISSILE HANDBOOK

RUSSIA

INTELLIGENCE REPORT

Russia's jack-rabbit start in the missile race created a big-booster gap. Repeated Sputnik firings conditioned most space enthusiasts to this realization. But the first man-in-space shot on April 12 still boomed out as startlingly as Big Ben at midnight. Much has been released about Major Gagarin's reaction to the flight. Little has been released about the booster that did the job.

What does Russia really have? Listed in this directory are 36 missiles that best intelligence indicates is the basic family of Russian missiles. It includes battle-field weapons and the big ICBM's that have doubled so well in the Soviet space program. It is the first complete rundown on Russian missile weaponry. Data was assembled for Aircraft & Missiles by George J. Geiger, aeronautical historian, through sources in Germany and France.

Extra copies of this directory available by writing: Handbook Supplement, Aircraft & Missiles, 56th & Chestnut Streets, Philadelphia 39, Penna. Price: $1.00 each, 3 for $2.00. Special rates on single address mailings in quantities of 50 or over.

SUPPLEMENT TO THIRD ANNUAL HANDBOOK ISSUE

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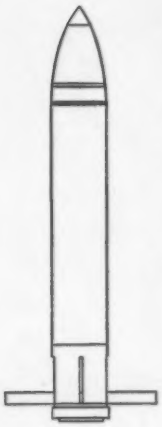


140MM ROCKET

Service: Army
Type: Battlefield Rocket
Status: Operational

Physical Data

Length: 3.4 ft
Diameter: 0.5 ft, 1.2 ft fin span
Weight: 120 lb
Powerplant: Solid propellant
Warhead: 55 lb high-explosive
Guidance: None

Remarks

Four pop-out folding fins. Range 9900 yds at Mach 1.6. First seen 7 Nov 1959 in Moscow. Identified as BM-14 also mounted on GAZ-63 truck. Used by Soviet Tank Forces.

280MM ROCKET

Service: Army
Type: Battlefield Rocket
Status: Operational

Physical Data

Length: 17.0 ft
Diameter: 1.2 ft, 2.2 ft fin span
Weight: 1000 lb
Powerplant: Solid propellant
Warhead: 483.5 lb high-explosive
Guidance: None

Remarks

Range 23,500 yd at Mach 1.7. First seen in late 1957. Mounted on YaAZ-214 heavy truck. Standard in all Soviet Artillery Regiments.

200MM ROCKET

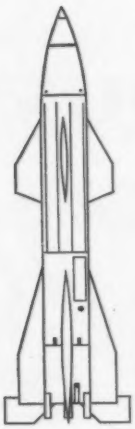
Service: Army
Type: Battlefield Rocket
Status: Operational

Physical Data

Length: 10.4 ft
Diameter: 0.9 ft, 1.3 ft fin span
Weight: 428 lb
Powerplant: Solid propellant
Warhead: 128.5 lb high-explosive
Guidance: None

Remarks

Range 20,000 yards at Mach 2.4. First seen in 1954. Four rd launcher mounted on ZIS/ZIL-151 truck. 75 launchers in each Soviet Tank Army.



C-2

Service: Air Force
Type: Surface-to-Air
Status: Training, phased out

Physical Data

Length: 25.8 ft
Diameter: 2.95 ft, 8.1 ft fin span
Weight: 8400 lb
Powerplant: Liquid engine, 17,160-lb thrust
Warhead: High-explosive
Guidance: Beam rider

Remarks

Range 25 mi at Mach 2.0. Ceiling 50,000 ft. Developed from WW II German "Wasserfall."

240MM ROCKET

Service: Army
Type: Battlefield Rocket
Status: Operational

Physical Data

Length: 4.2 ft
Diameter: 1.1 ft, no fins
Weight: 248 lb
Powerplant: Solid propellant, angled venturis
Warhead: 108.5 lb high-explosive
Guidance: None

Remarks

Range 7700 yds at Mach 1.5. First seen in late 1953. Mounted on either ZIS/ZIL-151 truck or AT-s tractor. Twelve in each Soviet Tank Division.

GOLEM 1

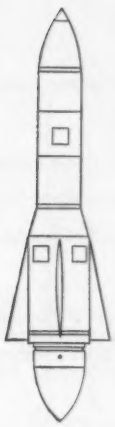
Service: Navy
Type: Underwater-to-Surface
Status: Operational

Physical Data

Length: 53.8 ft
Diameter: 5.5 ft, 11.2 ft fin span
Weight: 33,125 lb
Powerplant: Liquid engine, 121,200-lb thrust
Warhead: 2000 lb high-explosive or nuclear
Guidance: Programmed

Remarks

Range 395 mi at Mach 7.0. Two or three towed behind submerged submarine. Missile stands upright in water by flooding ballast chamber in tail.

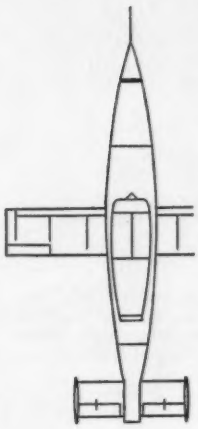


GOLEM 2

Service: Navy
Type: Underwater-to-Surface IRBM
Status: Operational

Physical Data
Length: 56.9 ft
Diameter: 7.2 ft, 13.2 ft fin span
Weight: 74,800 lb
Booster: Liquid engine, 242,000-lb thrust
Sustainer: Liquid engine, 71,500-lb thrust
Warhead: 1430 lb high-explosive or nuclear
Guidance: Programmed

Remarks
Range 1240 mi at Mach 11.4. Three missiles towed behind submerged submarine. Missile stands upright in water by flooding ballast chamber in tail.

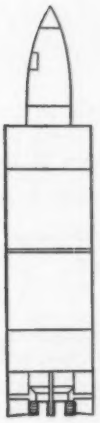


J-2

Service: Air Force, Army, Navy
Type: Target drone, Surface-to-Surface
Status: Operational

Physical Data
Length: 36.7 ft
Diameter: 4.5 ft, 23.7 ft wing span
Weight: 16,100 lb
Booster: Two solid propellant, 2000-lb thrust
Sustainer: 4850-lb thrust turbo-jet
Warhead: 2200 lb nuclear
Guidance: Radio

Remarks
Range 520 mi at Mach 0.87. Used from submarines. Fitted with cargo nose container to carry 3200 lb supplies to isolated troop units.

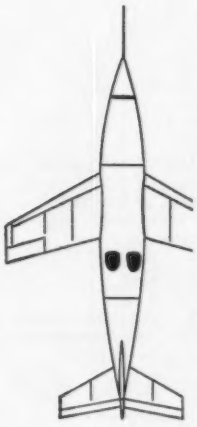


GOLEM 3

Service: Navy
Type: Underwater-to-Air
Status: Operational-development

Physical Data
Length: 17.2 ft
Diameter: 2.2 ft, 5.9 ft span
Weight: 4625 lb
Powerplant: Four solid propellant, 14,950-lb total thrust
Warhead: 175 lb high-explosive
Guidance: Infrared

Remarks
Range 7.5 mi at Mach 2.5. Ceiling 67,000 ft. Launched from tube by compressed air. Land version in development stage for Army.

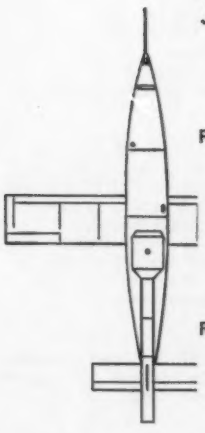


J-3

Service: Navy
Type: Surface-to-Surface IRBM
Status: Operational

Physical Data
Length: 37.2 ft
Diameter: 4.6 ft, 23.7 ft wing span
Weight: 20,900 lb
Booster: Four solid propellant, 4000-lb total thrust
Sustainer: Ram jet, 14,900-lb thrust
Warhead: 2200 lb nuclear
Guidance: Radio

Remarks
Range 1450 mi at Mach 1.15. Used from submarines. Possible use from cruiser type vessels.

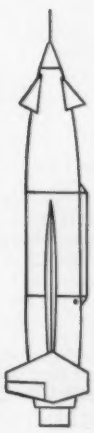


J-1

Service: Air Force, Army, Navy
Type: Target drone, Surface-to-Surface
Status: Operational

Physical Data
Length: 26.85 ft
Diameter: 3.0 ft, 20.75 ft wing span
Weight: 9700 lb
Booster: Two solid propellent, 2000-lb thrust
Sustainer: Pulse-jet, 1825-lb thrust
Warhead: 2650 lb high-explosive
Guidance: Radio

Remarks
Range 375 mi at Mach 0.65. Ceiling 21,300 ft.



KOMET D

Service: Air Force
Type: Air-to-Surface
Status: Development

Physical Data
Length: 15.0 ft
Diameter: 3.0 ft, 8.0 ft wing span
Weight: Unknown
Powerplant: Solid propellant, 3000 to 5000-lb thrust
Warhead: Thermonuclear
Guidance: Radio-radar

Remarks
Range 93 mi at Mach 0.85. Flight tested in 1957. Launched at 50,000 ft altitude from BISON or BEAR bomber.

ME(IGOR)

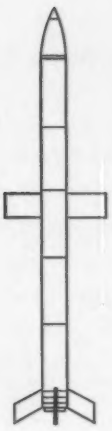
Service: Army
Type: Anti-tank
Status: Operational

Physical Data

Length: 4.0 ft
Diameter: 0.41 ft
Weight: 10.5 lb
Powerplant: Solid propellant
Warhead: 3.75 lb high-explosive
Guidance: None

Remarks

Range 2.25 mi at Mach 0.7. Two man firing team. Similar to U. S. "Bazooka." In production since 1946. Used throughout the Soviet Armed Forces.



M-100

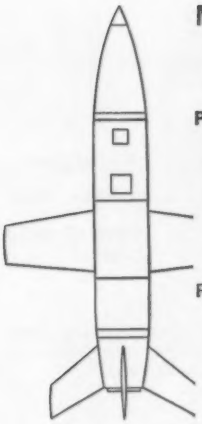
Service: Air Force
Type: Air-to-Air
Status: Operational, phased out

Physical Data

Length: 13.0 ft
Diameter: 0.9 ft, 3.0 ft wing span
Weight: 990 lb
Powerplant: Solid propellant 3400-lb thrust
Warhead: 336 lb high-explosive
Guidance: None

Remarks

Range 5 mi at Mach 0.96. Developed in 1947 by German technicians. Still used in the Arctic regions by the PVO (Anti-Air Defense Force).



M-1

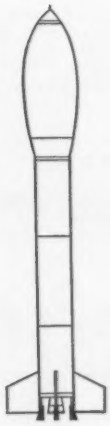
Service: Army
Type: Surface-to-Air
Status: Training, phased out

Physical Data

Length: 15.0 ft
Diameter: 2.0 ft, 10.0 ft wing span
Weight: 3300 lb
Booster: Three solid propellant
Sustainer: Walter type liquid engine
Warhead: High-explosive
Guidance: Inertial

Remarks

Velocity Mach 1.3. Developed about 1947. Also used as surface-to-surface tactical type missile.



M-100A

Service: Air Force
Type: Air-to-Air
Status: Operational

Physical Data

Length: 4.43 ft
Diameter: 0.26 ft, 1.0 ft fin span
Weight: 85 lb
Powerplant: Solid propellant 1000-lb thrust
Warhead: 20 lb high-explosive
Guidance: Infrared

Remarks

Range 3.4 to 5 mi at Mach 2.65. Control is by jet deflection. Also in an unguided version. Similar to GAR-3 "Falcon."

M-2

Service: Air Force, Army
Type: Surface-to-Air
Status: Operational

Physical Data

Length: 36.0 ft
Diameter: 1.6 ft, 5.3 ft fin span
Weight: 3970 lb
Booster: Solid, 9350-lb thrust
Sustainer: Solid, 4625-lb thrust
Warhead: 26.5 lb high-explosive
Guidance: Semi-active homing

Remarks

Range 37.25 mi at Mach 2.05. Ceiling 54,840 ft. First seen in 1957 in Moscow. Mounted on mobile trailer-launcher. New test version reported to reach 150,000 ft.

POL-1 and POL-2

Service: Air Force
Type: Target missile
Status: Operational-development

Physical Data

Length: (1) 14.27 ft, (2) 25.6 ft
Diameter: (1) 0.92 ft, (2) 2.3 ft
Weight: (1) 2400 lb, (2) 25,950 lb
Powerplant: Four solid propellant
(1) 7990 lb total thrust
(2) 90,650 lb total thrust
Payload: (1) 9.2 lb, (2) 90 lb
Guidance: (1) Programmed, (2) Inertial programmed

Remarks

POL-2 designed for IGY studies Recovered by means of a parachute in nose cone.

T-1 (M 101)

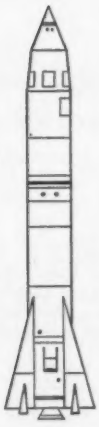
Service: Army, Navy
Type: Surface-to-Surface IRBM
Status: Operational

Physical Data

Length: 62.0 ft
Diameter: 5.6 ft, 12.0 ft fin span
Weight: 37,850 lb
Powerplant: Liquid engine 77,000-lb thrust
Warhead: 2650 lb nuclear
Guidance: Radio-inertial

Remarks

Range 400 to 600 mi. First seen in 1956 in Moscow. Copy of German A-4. Has transporter-erector trailer. Reports of over 3000 in use. Few given to Red China.



T-2 (M 103)

Service: Army
Type: Surface-to-Surface IRBM
Status: Operational

Physical Data

Length: 65.5 ft
Diameter: 8.5 ft, 17.0 fin span
Weight: 122,000 lb
Booster: M-103 liquid engine 268,000-lb thrust
Sustainer: Liquid engine 78,100-lb thrust
Warhead: 2240 lb nuclear
Guidance: Inertial

Remarks

Range 1800 mi at Mach 13.1. Copy of German A-10. Based in Satellite countries. Reports of 700 in service.

T-3 Mk 1 (M 104)

Service: Soviet Missile Command
Type: Surface-to-Surface ICBM
Status: Operational

Physical Data

Length: 88.5 ft
Diameter: 11.5 ft, 19.5 ft fin span
Weight: 176,000 lb
Booster: Three liquid engine, 480,000-lb total thrust
2nd Stage: Two liquid engine, 270,000-lb total thrust
3rd Stage: Liquid, 78,100-lb thrust
Warhead: 2200 lb thermonuclear
Guidance: Radio-inertial

Remarks

Range 4950 mi at Mach 20.0. In operational service 1959. Guidance housed in second stage.

T-3 Mk 2

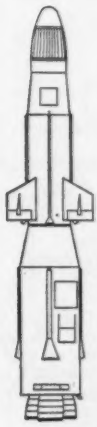
Service: Soviet Missile Command
Type: Surface-to-Surface ICBM
Status: Development

Physical Data

Length: 108.0 ft
Diameter: 16.0 ft, 23.5 ft fin span
Weight: 352,000 lb
Booster: Three liquid engines, 480,000-lb total thrust
2nd Stage: Two liquid engines, 270,000-lb total thrust
3rd Stage: Liquid engine, 78,100-lb thrust
Warhead: 2500 lb thermonuclear
Guidance: Inertial

Remarks

Range 6500 mi at Mach 20.7. First launched in 1957. Guidance in second stage. Used for launching satellites into space.



T-3A Mk 1

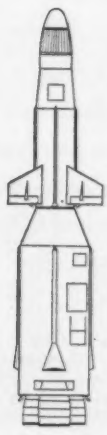
Service: Soviet Missile Command
Type: Surface-to-Surface ICBM
Status: Operational

Physical Data

Length: 91.5 ft
Diameter: 12.0 ft, 19.5 ft fin span
Weight: 176,000 lb
Sustainer: Two liquid engines, 268,000-lb total thrust
Booster: Four Liquid engines, 57,000-lb total thrust
Warhead: 1100 lb thermonuclear
Guidance: Programmed

Remarks

Range 6200 mi at Mach 21.5. Advance T-3 missile, using many T-3 component parts. Vernier engines for roll and directional control. Fired from fixed bases. In production and being considered for "hardened sites."



T-3A Mk 2

Service: Soviet Missile Command
Type: Surface-to-Surface ICBM
Status: Operational

Physical Data

Length: 101.5 ft
Diameter: 16.0 ft, 23.5 ft fin span
Weight: 396,000 lb
Booster: Four liquid engines, 820,000-lb total thrust
Sustainer: Two liquid engines, 268,000-lb thrust
Warhead: 1250 lb thermonuclear
Guidance: Programmed

Remarks

Range 6800 mi at Mach 22.1. Also in mass production. Fired from fixed bases. Reports that this version was used for the Soviet "man-in-space" project.

T-4 (M 102)

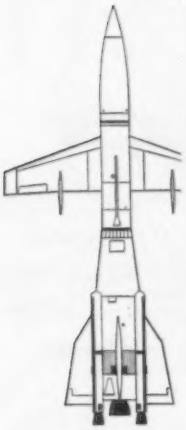
Service: Army
Type: Surface-to-Surface IRBM
Status: Operational-development

Physical Data

Length: 56.1 ft
Diameter: 7.2 ft, 14.0 ft fin span
Weight: 70,850 lb
Booster: Three liquid engines, 181,-950-lb total thrust
Sustainer: Liquid engine 52,800-lb thrust
Warhead: 1775 lb high-explosive
Guidance: Inertial

Remarks

Range 1000 mi at Mach 11.15. Developed from German A-10. Very elaborate guidance. Some versions fitted with stubby wings. Has not been too successful.



T-4A

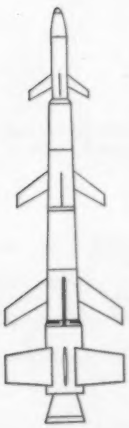
Service: Soviet Missile Command
Type: Surface-to-Surface ICBM
Status: Development

Physical Data

Length: 122.0 ft
Diameter: 10.2 ft, 63.8 ft wing span
Weight: 231,000 lb
Booster: Four solid propellant, 264,-000-lb total thrust
2nd Stage: Liquid engine, 264,000-lb thrust
3rd Stage: Liquid engine, 77,000-lb thrust
Warhead: 3080 lb nuclear
Guidance: Radio-programmed

Remarks

Range 12,500 mi at Mach 19.5. Existence confirmed December 1957. Soviet version of the German Sanger Project of anti-podal rocket bomber. Involved Soviet "man-in-space" projects.



T-5

Service: Army
Type: Surface-to-Air
Status: Training, phased out

Physical Data

Length: 32.2 ft
Diameter: 2.8 ft, 9.4 fin span
Weight: 4850 lb
Booster: Liquid engine, 83,500-lb thrust
2nd Stage: Solid propellant, 8200-lb thrust
3rd Stage: Solid propellant, 2300-lb thrust
4th Stage: Solid propellant, 440-lb thrust
Warhead: 458 lb high-explosive
Guidance: None

Remarks

Range 100 mi at Mach 4.35. Ceiling 211,200 ft. Identified in 1948. Copy of German "Rheinbote" design. Also used as surface-to-surface tactical missile.

T-5B

Service: Army
Type: Surface-to-Surface
Status: Operational

Physical Data

Length: 30.0 ft
Diameter: 2.5 ft, 5.0 ft fin span
Weight: 5750 lb
Powerplant: Solid propellant, 22,-000-lb thrust
Warhead: 1180 lb high-explosive or nuclear
Guidance: None

Remarks

Range 25 mi at Mach 2.3. First seen in 1957. Mounted on KW-85 or Joseph Stalin II AFV tank chassis. Standard in all Soviet Armored Units.

T-5C

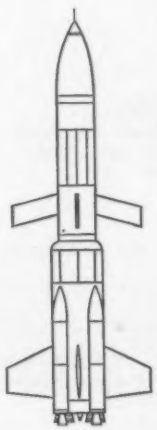
Service: Army
Type: Surface-to-Surface
Status: Operational

Physical Data

Length: 25.0 ft
Diameter: 1.1 ft, 2.1 ft fin span
Weight: 4400 lb
Powerplant: Solid propellant, 23,200-lb thrust
Warhead: 1100 lb high-explosive or nuclear
Guidance: None

Remarks

Range 25 mi at Mach 3.3. Introduced in November 1957. Mounted on PT-76 amphibian tank chassis. Very mobile. New version with different shaped warhead now in production.



T-6

Service: Air Force, Army
Type: Surface-to-Air
Status: Operational

Physical Data

Length: 22.0 ft
Diameter: 2.7 ft, 7.9 ft fin span
Weight: 4000 lb
Booster: Four solid propellant, 10,-580-lb total thrust
Sustainer: Two solid propellant, 2200-lb thrust
Warhead: 88 lb high-explosive
Guidance: Radar

Remarks

Range 25 mi at Mach 2.4. Ceiling 62,000 ft. Finned nose cone separated by explosive bolts and warhead coasts to target on ballistic trajectory. In wide use, claimed highly efficient for air defense.

T-7

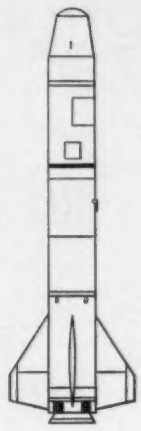
Service: Air Force
Type: Surface-to-Air
Status: Operational

Physical Data

Length: 30.1 ft
Diameter: 2.6 ft, 9.1 ft fin span
Weight: 5050 lb
Powerplant: Two liquid engines, 22,400-lb total thrust
Warhead: 407 lb high-explosive
Guidance: Radar

Remarks

Range 60 mi at Mach 5.9. Ceiling 100,000 ft. Originally a high altitude research vehicle. Produced at an assembly plant near Moscow.



T-9 (KOMET 1)

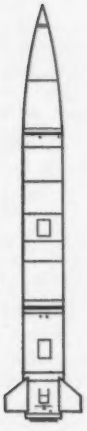
Service: Soviet Missile Command
Type: Surface-to-Surface
Status: Operational

Physical Data

Length: 36.8 ft
Diameter: 4.26 ft, 10.9 ft fin span
Weight: 20,250 lb
Powerplant: Solid propellant 53,250-lb thrust
Warhead: 460 lb high-explosive
Guidance: None

Remarks

Range 102.5 mi at Mach 4.25. Used to test T-10 (KOMET 2) nose cone. Navy launches T-9 from submarines, missiles stored in conning tower. Also identified as CH-17. Said to be in operation with Red China Navy.



T-7A

Service: Army
Type: Surface-to-Surface
Status: Operational

Physical Data

Length: 27.8 ft
Diameter: 2.7 ft, 9.6 ft fin span
Weight: 8800 lb
Powerplant: Solid propellant 11,450-lb thrust
Warhead: 1770 lb high-explosive or nuclear
Guidance: Radio-inertial

Remarks

Range 100 mi at Mach 4.2. Mounted on KW-85 tank chassis. Launched from vertical position. Very mobile. Comparable to U. S. Army "Corporal" missile.

T-10 (KOMET 2)

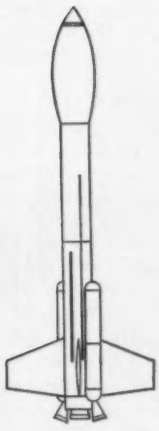
Service: Soviet Missile Command
Type: Surface-to-Surface IRBM
Status: Operational

Physical Data

Length: 42.4 ft
Diameter: 5.9 ft, 10.9 ft fin span
Weight: 41,350 lb
Powerplant: Solid propellant 99,000-lb thrust
Warhead: 550 lb high-explosive
Guidance: Inertial

Remarks

Range 620 mi at Mach 7.5. In production in the USSR and East Germany. Reports of some 3200 KOMET 1 & 2's being produced each month. Used from submarines by the Red Navy.



T-8

Service: PVO (Air Force)
Type: Surface-to-Air
Status: Operational

Physical Data

Length: 13.6 ft
Diameter: 1.05 ft, 4.8 ft fin span
Weight: 2090 lb
Booster: Two solid propellant, 4000-lb total thrust
Sustainer: Liquid engine, 4600-lb thrust
Warhead: 14.9 lb high-explosive
Guidance: Infrared

Remarks

Range 15 mi at Mach 2.2. Ceiling 79,280 ft. Soviets claim 98 per cent kill rate against J-1 target drones. Deployed in field batteries, six launchers to a battery. Operational since 1954.

TYPE 2

Service: Air Force
Type: Air-to-Air
Status: Operational-development

Physical Data

Length: 15.0 ft
Diameter: 0.85 ft, 2.65 ft wing span
Weight: 1120 lb
Powerplant: Solid propellant 8750-lb thrust
Warhead: 550 lb high-explosive
Guidance: Infrared

Remarks

Range 5.5 mi at Mach 2.75. Improved version of the old M-100. Warhead fitted with proximity fuse. Also used for air-to-surface.

SUMMARY OF SOVIET MISSILES AND ROCKETS

DESIGNATION	Guidance	POWERPLANT 1st Stage Type	1st Stage lbs/T	2nd Stage Type	2nd Stage lbs/T	3rd Stage Type	3rd Stage lbs/T	SIZE AND PERFORMANCE Weight lbs	Length ft	Diameter ft	Span ft	Range miles	Mach No.	Ceiling	WARHEAD Type	Wgt (lbs)	Remarks
AIR-TO-AIR																	
M-100	None	SR	3400					990	13.0	0.9	3.0	5	0.96		HE	336	Train
M-100A	IR	SR	1000					85	4.43	0.26	1.0	5	2.65		HE	20	Op
TYPE 2	IR	SR	8750					1120	15.0	0.85	2.65	5.5	2.75		HE	555	Dev
AIR-TO-SURFACE																	
KOMET D	RA-RD	SR	5000						15.0	3.0	8.0	93	0.85		TN		Dev
BATTLEFIELD																	
140mm	None	SR						120	3.4	0.5	1.2	5.7	1.6		HE	55	Op
200mm	None	SR						428	10.4	0.9		11.5	2.4		HE	128.5	Op
240mm	None	SR						248	4.2	1.1		4.5	1.5		HE	108.5	Op
280mm	None	SR						1000	17.0	1.2	2.2	13.5	1.7		HE	483.5	Op
ME (IGOR)	None	SR						10.5	4.0	0.41		2.25	0.7		HE	3.75	Op
IRBM																	
J-3	RA	4SR	4000	RJ	14,900			20,900	37.2	4.6	23.7	1450	1.15	10.25 mi	N	2200	Op Navy
T-1 (M101)	RA-Int	LR	77,000					37,850	62.0	5.6	12.0	600	7.0	132 mi	N	2650	Op
T-2 (M103)	Int	LR	268,000	LR	78,100			122,000	65.5	8.5	17.0	1800	13.1	120 mi	N	2240	Op
T-4 (M102)	Int	3LR	181,950	LR	52,800			70,850	56.1	7.2	14.0	1000	11.15	227 mi	HE	1775	Dev
T-10 (KOMET 2)	Int	SR	99,000					41,350	42.2	5.9	10.9	620	7.5	195 mi	HE	550	Op Navy
ICBM																	
T-3 (M104) Mk 1	RA-Int	3LR	480,000	2LR	270,000	LR	78,100	176,000	88.5	11.5	19.5	4950	20.0	570 mi	TN	2200	Op
T-3 Mk 2	Int	3LR	480,000	2LR	270,000	LR	78,100	352,000	108.0	16.0	23.5	6500	20.7	576 mi	TN	2500	Dev
T-3A Mk 1	Prog	4LR	517,000	2LR	268,000			176,000	91.5	12.0	19.5	6200	21.5	960 mi	TN	1100	Op
T-3A Mk 2	Prog	4LR	520,000	2LR	268,000			396,000	101.5	16.0	23.5	6800	22.1	960 mi	TN	1250	Op
T-4A	RA-Prog	4SR	264,000	LR	264,000	LR	77,000	231,000	122.0	10.2	63.8	12,500	19.5	235 mi	N	3080	Dev
SURFACE-TO-AIR																	
C-2	BR	LR	17,160					8400	25.8	2.85	8.1	25	2.0	50,000 ft	HE		Train
M-1	Int	3SR		LR				3300	15.0	2.0	10.0		1.3		HE		Train
M-2	SAH	SR	9350	SR	4625			3970	36.0	1.6	5.3	37.25	2.05	54,840 ft	HE	26.5	Op
T-5*	None	SR	8200	SR	2300	SR	440	4850	32.2	2.8	9.4	100	4.35	40 mi	HE	458	Train
T-6	RD	2SR	10,580	2SR	2200			4000	22.0	2.7	7.9	25	2.4	62,000 ft	HE	88	Op
T-7	RD	2LR	22,400					5050	30.1	2.6	9.1	60	5.9	100,000 ft	HE	407	Op
T-8	IR	2SR	4000	LE	4600			2090	13.6	1.05	4.8	15	2.2	79,280 ft	HE	14.9	Op
		* Fourth stage T-5 liquid rocket 83,500 lb thrust															
TACTICAL																	
T-5B	None	SR	22,000					5750	30.0	2.5	5.0	25	2.3		HE-N	1180	Op
T-5C	None	SR	23,200					4400	25.0	1.1	2.1	25	3.3		HE-N	1100	Op
T-7A	RA-Int	SR	11,450					8800	28.8	2.7	9.6	100	4.2	44.7 mi	HE-N	1770	Op
T-9 (KOMET 1)	None	SR	53,250					20,250	36.8	4.26	10.9	102.5	4.25	42.3 mi	HE	460	Op
TARGET MISSILES																	
J-1	RA	2SR	2000	PJ	1825			9700	26.85	3.0	20.75	375	0.65	21,300 ft	HE	2650	Op Navy
J-2	RA	2SR	2000	TJ	4850			16,100	36.7	4.5	23.7	520	0.87	6.8 mi	HE-N	2200	Op Navy
POL-1	Prog	4SR	7990					2400	14.27	0.92			4.36		Inst	9.2	Op
POL-2	Prog-Int	4SR	90,650					25,950	25.6	2.3			7.12		Inst	90	Op
UNDERWATER																	
Golem 1	Prog	LR	121,200					33,125	53.8	5.5	11.2	395	7.0		HE-N	2000	Op Navy
Golem 2	Prog	LR	242,000	LR	71,500			74,800	56.9	7.2	13.2	1240	11.4		HE-N	1430	Navy IRBM
Golem 3	IR	4SR	14,950					4625	17.2	2.2	5.9	7.45	2.5	67,000 ft	HE	175	Op Navy

ABBREVIATIONS

BR—beam rider.
Dev—development.
HE—high-explosive.
Inst—instruments.
Int—inertial.
IR—infra-red.
LR—liquid rocket.
N—nuclear.
OP—operational.
PJ—pulse-jet.
Prog—programmed.
RA—radio.
RD—radar.
RJ—ram-jet.
SAH—semi-active homing.
SR—solid rocket.
T—thrust.
TJ—turbo-jet.
TN—thermonuclear.

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Handy reference page on the physical properties of both Teflon & Kel-F. —*Tetrafluor, Inc.*

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Planar Devices

Brochure describes in detail the technology of the planar process and the reliability, performance, cost and adaptability of planar devices.—*Fairchild Semiconductor Corp.*

Circle 65 on Inquiry Card for more data

Ceramics Standards

Book contains a wide range of data relating to the production, design, purchasing, and use of alumina ceramic materials—*Diamonite Products Mfg.*

Circle 66 on Inquiry Card for more data

Diminutive Devices

Handbook is designed to assist the engineer in selection and application of Electro-Magnetic Clutches/Brakes —Mechanical Clutches—Torque Indicators—Torque Standards and Multispeed Transmissions. —*Atotronics, Inc.*

Circle 67 on Inquiry Card for more data

Semiconductor Production

"The Way to Better Semiconductor Production" describes and illustrates many pieces of equipment now built for precision control in the production of semiconductors.—*Lindberg Engineering Co.*

Circle 68 on Inquiry Card for more data

Catalog on Switches

Specifications, details, and prices on Low Pressure Switches and Velocity Actuated Flow Switches are described in a 30-page catalog.—*Henry G. Dietz Co., Inc.*

Circle 69 on Inquiry Card for more data

Automatic Handling

Illustrated, 24-page booklet describes remotely controlled handling equipment available for remote handling problems in nuclear, space, underseas, and industrial environments.—*General Mills, Inc.*

Circle 70 on Inquiry Card for more data

Perpendicularity

Technical bulletin reviews a new self-aligning locknut—SPS SA 16—that compensates for out-of-squareness conditions as great as 8 degrees.—*Standard Pressed Steel Co.*

Circle 71 on Inquiry Card for more data

Soldering System

An automatic wave and jet soldering system for high-volume production soldering of printed circuit boards and in-line terminals, is described in a six-page brochure.—*Special Products Div. of Compo Shoe Machinery Corp.*

Circle 72 on Inquiry Card for more data

Granite Plates

A special line of oversize granite surface plates for precision measurement of large parts and assemblies is described and illustrated in a 4-page bulletin.—*Herman Stone Co.*

Circle 73 on Inquiry Card for more data

Digital Transducers

A set of six technical bulletins including features, characteristics and outline drawings of digital transducers and subminiature pressure instruments.—*DeJur-Amsco Corp.*

Circle 74 on Inquiry Card for more data

Automation Center

Brochure explains generally the services offered in management con-

continued on page 60

Authoritative help for engineers...

NONDESTRUCTIVE TESTING HANDBOOK

This pioneering Handbook covers all the means of testing the essential properties and performance capabilities of materials, parts, components, and structures *without impairing serviceability.*

Explains and illustrates applications, advantages, limitations of 24 different test methods applicable in every branch of engineering and industry. Specifications, equipment costs, hundreds of pages of test interpretation data. *Prepared under the auspices of the Society for Nondestructive Testing. 1,100 illustrations, graphs, tables; 1,910 pp. 106 Contributing, Consulting Editors. Robert C. McMaster, Ed. 1959.* 2 volumes, $24

PRODUCTION HANDBOOK

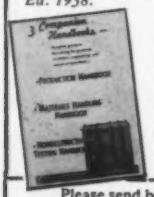
Packed with practical production know-how, this Handbook is the complete key to management-engineering methods that are revolutionizing industrial production today. Fully covers new materials, machines, processes, and proper functioning of company organization.

Supplies proved principles, time- and work-saving systems, and successful operating procedures for maximum productivity at minimum cost. Saves hours of research and costly experimentation. *726 illustrations, tables; 1,726 pp. 48 Contributing, Consulting Editors. Gordon B. Carson, Ed. 2nd Ed., 1958.* $16

MATERIALS HANDLING HANDBOOK

The complete guide to modern materials handling. This unique Handbook explains the governing principles, today's most efficient methods and systems, and recommended equipment for moving material at least cost — whether in raw, in-process, or finished form.

Useful in all industrial situations. Handbook answers every basic question of work flow within and outside the plant. *Sponsored by The American Society of Mechanical Engineers and the American Material Handling Society. 991 illustrations, tables; 1,740 pp. 84 Contributing, Consulting Editors. Harold A. Bolz, Ed.; George E. Hagemann, Assoc. Ed. 1958.* $20



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Circle 15 on Inquiry Card

Worth Asking For

. . . *continued from page 59*

sulting, systems design, programming and data processing.—*McDonnell Automation Center.*

Circle 75 on Inquiry Card for more data

Delay Line

Brochure explains in detail the operational theory of magnetostrictive lines and their advantages and ranges of capabilities, in use applications are described. One such application is the use of sonic delay lines as digital memory and storage devices.—*Computer Control Co.*

Circle 76 on Inquiry Card for more data

Trim Pots

Data bulletin describes electrical, environmental, and mechanical parameters of a line of microminiature wire wound trimming potentiometers and variable resistors. Cutaway views show functional configuration of the devices.—*Edcliff Instruments.*

Circle 77 on Inquiry Card for more data

Space Simulators

Facilities brochure describes the services offered in the simulation of extreme altitudes, temperatures and motion. Solar simulation for the approximation of solar energy distribution is also afforded.—*Tenney Engineering, Inc.*

Circle 78 on Inquiry Card for more data

Pyrometer Indicator

Bulletin details a portable pyrometer indicator for temperature-milivolt measurement. Indicator weighs 3½ lbs and measures 4x5x6 in.—*Thermo Electric Co., Inc.*

Circle 79 on Inquiry Card for more data

Products—Facilities

Booklet describes products designed and manufactured for the aircraft and missile industry, also tells of research, engineering, and testing capabilities.—*Walter Kidde & Co.,*

Circle 80 on Inquiry Card for more data

Flame Retardant Resin

A new epoxy resin for hot-melt castings and dry lay-up laminating systems is described in a 4-page brochure. Instructions for use of the resin and tables illustrating properties are included. *Union Carbide Plastics Co.*

Circle 81 on Inquiry Card for more data

Rectilinear Recorders

Booklet gives cost, size, electrical and mechanical specs., and applications of portable and stationary models.—*Curtiss Wright Corp.*

Circle 82 on Inquiry Card for more data

Ball-Piston Pumps

Six-page bulletin discusses design, operation, applications and efficiency of variable delivery ball-piston pumps for advanced hydraulic systems. Specifications, a performance curve and a schematic diagram of the pumps are included.—*General Electric Co.*

Circle 83 on Inquiry Card for more data

Ultraviolet Spectrophotometer

Sixteen-page brochure describes major features, outlines specs., and explains the optical system and operating principles of a double beam spectrophotometer.—*Beckman Instruments Div.*

Circle 84 on Inquiry Card for more data

Semiconductor Selector

A guide which includes technical data on devices for military application and lists the mechanical construction and electrical ratings of each.—*Sylvania Electric Prods., Inc.*

Circle 85 on Inquiry Card for more data

Facilities Brochure

Enlarged and newly added terminals and shop facilities along with a relocation of the central office are explained in a six-page brochure. Moves designed to expedite the transportation of manned and unmanned aircrafts.—*U.S.A.C. Transport Inc.*

Circle 86 on Inquiry Card for more data

Layer Circuitry

Printed circuit technique enables six layers of circuitry to be compacted into a plane just .036" thick plus supporting substrate. Bulletin available.—*Intellux Inc.*

Circle 87 on Inquiry Card for more data

Special Coatings

Four-page folder describes 18 special industrial coatings with a variety of problem-solving applications for the aviation industry, particularly in the manufacture and protection of parts and components of metal, rubber, plastics. Coatings are designed for dry lubrication, mold or die release, and protection of products.—*Johnson's Wax.*

Circle 88 on Inquiry Card for more data

Flexible Laminates

Flexible laminates for temperature classes A and B are described in an eight-page brochure that lists standard combinations and typical properties of varnished cambric and polyester film laminations with other materials, including fish, rag, kraft and asbestos papers, and glass fabrics.—*Irvington Div., M.M.M.*

Circle 89 on Inquiry Card for more data

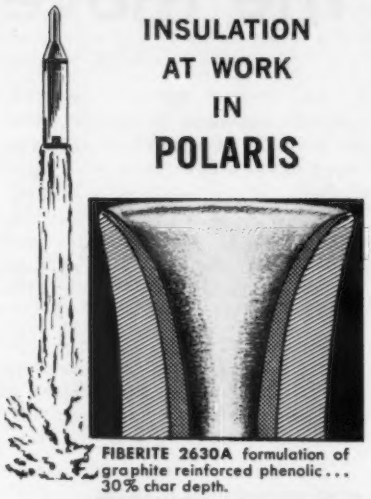
Equipment Catalog

Bulletin on selective plating equipment describes several "package" plating plants, some of which are small enough to fit on a table top.

example...

FIBERITE

INSULATION AT WORK IN POLARIS



FIBERITE 2630A formulation of graphite reinforced phenolic... 30% char depth.

Char Depth

Standard graphite reinforced phenolic 100% char depth.

The development of special Fiberite MX 2630A formulations reduce char depth of graphite reinforced phenolic molded insulations up to 70%, thus permitting the use of these materials in more critical solid propellant rocket motors.

Cut-away sections above illustrate reduction of char depth by utilizing Fiberite molding material.

EXPLORE FIBERITE

Missile engineers will find our research helpful in solving problems requiring materials for special performance. Write factory for bulletin "Fiberite High Temperature Insulating Materials."

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FIBERITE

THE FIBERITE CORPORATION

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514 W. 4th Street
Winona, Minnesota

MOLDING COMPOUNDS

Circle 16 on Inquiry Card

The bulletin also lists more than two dozen engineering applications, typical of these are touch-up of damaged areas without disassembly, resizing of mismachined components and easy two-tone plating.—*Selectrons, Ltd.*

Circle 90 on Inquiry Card for more data

Temperature Sensors

Eight page bulletin, #2000 describes platinum-resistance temperature transducers designed for use with cryogenic fluids, such as liquid hydrogen and LOX, the sensors are suitable for airborne or ground based applications.—*Trans-Sonics, Inc.*

Circle 91 on Inquiry Card for more data

Hardfacing

Brochure on Hardfacing electrodes and wires in which all the hardfacing materials are classified and illustrated according to use. Wear protection provided on industrial and construction equipment is discussed in detail. —*Air Reduction, Inc.*

Circle 92 on Inquiry Card for more data

Cabinet Racks

Catalog contains illustrations, descriptions, complete specifications, and prices of cabinet racks and consoles for modular assembly. — *Par-Metal Products Corp.*

Circle 93 on Inquiry Card for more data

Seals & Packings

Catalog which describes and illustrates the various types, sizes, operating features and advantages of a complete line of solid urethane hydraulic seals and packings.—*Disogrin Industries.*

Circle 94 on Inquiry Card for more data

Pneumatic Check Valves

Bulletin describing a line of piston-type pneumatic check valves for handling ballistic gases in aircraft ejection seat and canopy systems.—*Allen Aircraft Products, Inc.*

Circle 95 on Inquiry Card for more data

Multi-Mode Tube

Brochure describing the operation of a multi-mode Tronotron storage tube compares the operation of conventional storage tubes with the Multi-Mode tube which employs bombardment induced conductivity as well as secondary emission effects. — *Hughes Aircraft Co.*

Circle 96 on Inquiry Card for more data

Relay Catalog

Catalog which illustrates, describes and gives circuit and application diagrams for a line of SPDT, DPDT and 3PDT "Micro-Scan" relays that have an operating time of less than 650 microseconds and a life span of 1 million operations. — *James Electronics Inc.*

Circle 97 on Inquiry Card for more data

ROCKET ENGINE HANDLING?

Pneuma-Grip® solves problem of removing and inserting engines without damage to highly sensitive surfaces. Pneumatic rubber rings contact maximum area at minimum psi.

For 8-page descriptive catalog write:

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WEST COAST:
Integrated Handling Systems
941 Charleston Road
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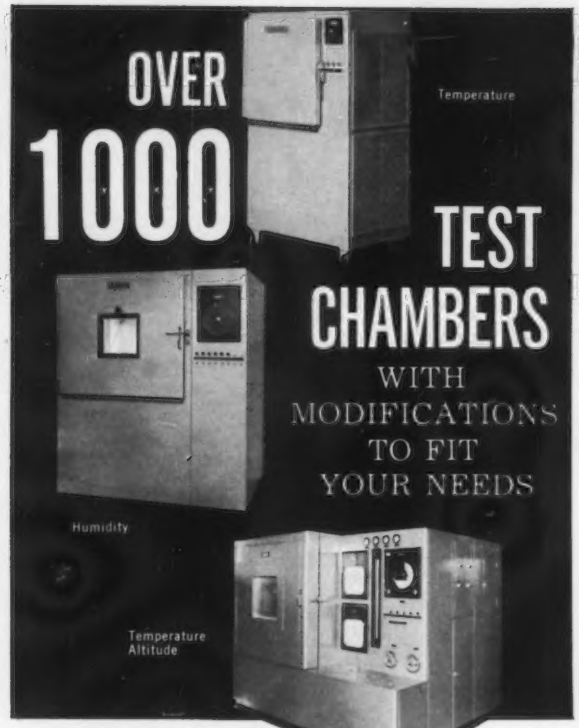
U.S. Pat. No. 2,894,780

Also manufacturers of Pneuma-Seal for critical sealing problems

Unit shown was developed for the Saturn Rocket Program being conducted by the George C. Marshall Space Flight Center, Huntsville, Alabama.

Circle 17 on Inquiry Card



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That's right! At Missimers you are offered a complete line of standard, advanced, high-quality equipment for both environmental testing and production process needs. And where specialized systems are necessary, a wide background of experience gained over 25 years is at your service.

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Men on the Move

Dr. Vincent Berinati
Aerospace Corp.

DR. VINCENT BERINATI, a flight systems engineer, is now technical assistant to the director of Aerospace Corp.

FREDERICK R. HAYS has been appointed to the post of senior staff physicist at American Optical Company's Research Center.

STEPHEN J. JATRAS named general manager of Avionics and Industrial Products Div. and vice-president of Lockheed Electronics Co.

Benjamin F. Ruffner
Boeing

BENJAMIN F. RUFFNER named chief of technical staff at Boeing's Aero-Space Div., in this position he will supervise the various technology departments.

DR. ALBERT B. VAN RENNES named director for European scientific and technical liaison by the Bendix Corporation.

Gordon B. Knoob
Motorola

GORDON B. KNOOB appointed staff engineer in the program planning department of Motorola's Military Electronics Div.

W. T. NOLL appointed a divisional vice-president of Minneapolis-Honeywell's Aeronautical Div.

Dr. D. C. Schiavone
Martin

DR. DANIEL C. SCHIAVONE, rocket engine authority, has been named director of reliability on the engineering staff of The Martin Company.

JOHN P. LEAHAN has been appointed manager of industrial planning for the Aerospace-Rockets Div. of Bell Aerosystems Co.

L. D. BROWN has been named to the post of chief engineer at Aerotest Laboratories.

John R. Sosoka
Unitek

JOHN R. SOSOKA named manager of application engineering for the Weldmatic Div. of Unitek Corp.

CHARLES R. ABLE and JACKSON R. MCGOWEN have been elected to the board of Douglas Aircraft Co.

RALPH H. RUUD elected a vice-president of North American Aviation Inc. and president of their Los Angeles Div.

R. W. DE NOBEL has been named supervisor of a 14 man research group recently formed at Vitro Labs.

LAURENCE M. SILVA is now chief engineer at Electrosolids Corp., in his new post he will manage all engineering activities.

DR. WALTER R. HEDEMAN named coordinator of advanced development, engineering div. at General Precision, Inc.

DR. RAYMOND DUHAMEL has joined Hughes Aircraft Company as senior staff scientist in the radar laboratory.

CARL R. WETTERAU, formerly president of Flight Support, has joined Greer Hydraulic Inc. as assistant chief engineer.

MAJ. GEN. MARVIN L. MCNICKLE named Air Material Command's Director of Supply-U.S.A.F.

BERTRAM MAGENHEIM has been named chief engineer of Control Electronics Company.

DR. LUKE HARVEY POE, JR., has been appointed assistant to the president at Aerojet-General Corp.

LOUIS L. REASOR appointed manager of Hughes Aircraft Co.'s Tuscon div. and EDWARD A. HAYES named as assistant manager.

D. W. KRAYBILL named project manager—Saturn for the Astronautics Div. of Chance Vought Corporation.

DR. FRED SINGER was recently made a member of the board of directors at the Decker Corp.

GEORGE F. HOULROYD has been elected vice pres.-manufacturing at Foto-Video Electronics, Inc., Cedar Grove, N. J.

DR. CARL L. KOBER has been named director of advanced programs for The Martin Co.'s Denver Division.

Ralph H. Ruud
North American

Laurence M. Silva
Electrosolids

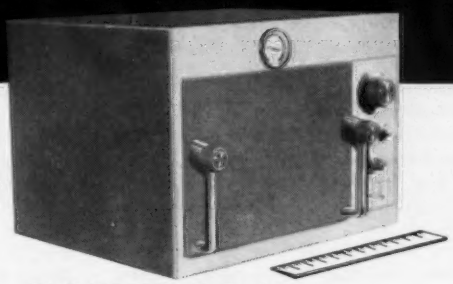
Carl R. Wetterau
Greer

Louis L. Reasor
Hughes

Edward A. Hayes
Hughes

George F. Houlroyd
Foto-Video

NEW! WYLE
Miniature Temperature Chamber
For Small Parts and Black Boxes



Wyle Model C-106 Miniature Chamber

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CLOSER TEMPERATURE CONTROL • COOLER OUTSIDE SKIN • BETTER OPERATING ECONOMY • GREATER FLEXIBILITY • FASTER HEATING & COOLING RATES

Revolutionary NEW "Sensor" The new Wyle liquid CO_2-cooled Model C-106 Miniature Temperature Chamber is the first to use a revolutionary new type electronic resistance bulb controller that "anticipates" temperature changes and thus effects minimum variation over the full range.

Extra thick layers of new, improved insulation retard flow of heat to outside skin . . . skin stays cooler. Interchangeable plug-in doors, with various provisions for specimen mounting, instrumentation, specimen operation, and observation, assure minimum downtime. All features lead to greater economy of operation.

RACK...STACK...OR SIDE-BY-SIDE MOUNTING

Fits standard 19" racks . . . Flush top & bottom . . . Flush sides

640 Cu. In. Capacity • −100°F to +500°F Range • 8" x 8" x 10" Test Volume Dimensions • Weight . . . Approx. 55 Lbs. • Heating & Cooling Rates . . . Up to 100°F per Minute

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New Books

AMERICA: TOO YOUNG TO DIE! By Major Alexander P. De Seversky. McGraw-Hill, 1961. 237 pp., $4.95. This distinguished author, flyer and scientist needs no introduction to the generations which grew with air power. He now presents a provocative appraisal of air power in the course of past human events, and views the aerospace power of today and tomorrow as the key to survival. He directs his criticisms, in no uncertain terms, to the bureaucratic forces which have impeded the fullest expression of military power in the air. He maintains that the same archaic thinking is today widening the aerospace gap between the United States and Russia. He warns that unless an immediate nationwide effort is made to mobilize America's latent intellectual resources, it will be too late to try anything.

THE EXPLORATION OF SPACE. By Arthur C. Clarke. Fawcett, 1960. 192 pp. $0.50. A very readable paper-back edition, written for the space-minded layman. It discusses the nature of the challenge, explains by clear analogies the physical laws involved, and answers some of the most-frequently asked questions on rocket propulsion, gravity, space navigation, communications, space stations, etc.

SCIENCE PROJECTS HANDBOOK. Edited by Shirley Moore Science Clubs of America. Science Service and Ballantine Books, 1960. 253 pp., $0.50. Over a thousand ideas for work projects and experiments are presented in this book for youthful scientists. It is written for the budding scientists of elementary schools or in junior or senior secondary schools. Fields covered include: Botany, Chemistry, Electronics, Entomology, Geology, Mathematics, Medical Sciences, Physics, Space Sciences, and Zoology. A list is also included of over 300 science books and magazines in these fields.

WHAT IS GRAVITY? By Walter F. Dimmick, 1961. 30 pp., $2.00. This booklet is an illustrated presentation of Dimmick's theory of gravitation. The first paper on this theory was published in 1959 under the title of "Gravitation and Magnetism," A Unified Principle. This theory explains gravitation, magnetism, inertia and centrifugal force as manifestations of electromagnetic field phenomena.

THE TRUE BOOK ABOUT SPACE TRAVEL. By Kenneth Johns. Muller, 1960. 144 pp., $2.75. Space exploration treated in a popular vein, against an historical backdrop. A larger-than-usual type size, imaginative illustrations, and non-technical treatment make this an interesting booklet for youthful readers.

SPACE BIOLOGY — THE HUMAN FACTORS IN SPACE FLIGHT. By James Stephen Hanrahan and David Bushnell. Basic Books, 1960. 263 pp., $6.00. This is an historical survey of man's efforts to gather information on the many unknowns that will affect his living processes in the space environment. The impact of space exploration is analyzed from the vantage point of the individual, as well as that of the human society as a whole. Major subdivisions of the book cover the following topics: The space vehicle and its internal environment; g-forces and weightlessness problems; radiation hazards; impact of astronautics upon mankind. A 39-page bibliography is also included.

FUNDAMENTALS OF STRESS ANALYSIS (Second Edition). By Albert Deyarmond and Albert Arslan. Aero Publishers, 1960. 256 pp., $5.75. The subject matter is oriented particularly for engineers in the aircraft and missile industries. Practical examples are provided throughout, as they apply directly to wings, fuselages and missile-shell analysis. Chapter coverage includes: structural design procedure, various types of structures, stress and strain, forces and couples, laws of statics, reactions, structures with axial loads in members, beams, torsion, section properties, allowable stresses.

AMERICAN STRATEGY FOR THE NUCLEAR AGE. Edited by Walter F. Hahn and John C. Neff. Doubleday, 1960. 455 pp., $1.45. Published under the auspices of the Institute for American Strategy, this book is a compilation of the reflections and statements of eminent authors on such pressing questions as: What is the changed global environment in which we find ourselves today? What is the nature of our enemy—his strengths, weaknesses, strategy and tactics? What is the scope of the military challenges confronting us? What are the economic policies by which we can meet the challenge? What are some of the specific courses of action which should be taken if we are to win the struggle?

THE MEASURE OF MAN—HUMAN FACTORS IN DESIGN. By Henry Dreyfuss. Whitney, 1960. $4.95. A portfolio containing 16 charts of anthropometric data, a booklet, and two full-size (6 x 2 ft) charts on human factors. Valuable facts are given on the range of human physique measurements and mechanical capabilities. Designers of combat vehicles, cockpit controls and display systems, and space capsules would find this data very useful in their work.

REACHING FOR THE STARS. By Erik Bergaust. Doubleday, 1960. 407 pp., $4.95. The author considers this an "unauthorized biography" based on his personal acquaintance of Dr. Wernher von Braun—the man who has in the past is at the present bringing space exploration to fruition. Flavored with many episodes and anecdotes, the colorful and inspiring life story of von Braun is covered from boyhood to its fulfillments of today.

THEORY OF INERTIAL GUIDANCE. By Connie L. McClure. Prentice Hall, 1960. 340 pp. $12.00. Here are the basics of inertial systems and their elemental configurations of inertial systems used in stabilization, navigation and guidance. The author presupposes an undergraduate background in mathematics and elementary mechanics. Chapters are devoted to the following topics: the cosmic environment, cartesian transformations and the vector concept, fundamentals of vector analysis, kinematic fundamentals, rigid body dynamics, gyrodynamics, theory of stabilized platforms, single channel descriptions of terrestrial inertial systems, terrestrial inertial guidance.

PLASMA DYNAMICS. Edited by Francis H. Clauser. Addison-Wesley, 1960. 369 pp., $12.00. This volume is based on an international symposium on plasma dynamics held at Woods Hole, Mass., June 9-13, 1958, sponsored by the National Academy of Sciences and the Office of Scientific Research, Air Research and Development Command. This book should be of particular value to thermonuclear physicists, missile and space engineers, astrophysicists and electronics engineers. Major topical areas included are: experimental research on high-temperature plasmas; problems of thermonuclear fusion and high-temperature plasmas.

New Materials

Bearing Finish

Ball bearing finish is said to provide smoother surfaces and corners for greater resistance to corrosion.

Process, called Brite-Gard, provides polished finish which resists adherence of dirt.—New Departure Div., GMC.

Circle 98 on Inquiry Card for more data

Glass-Epoxy Laminate

Glass-base, epoxy-resin laminated plastic is self-extinguishing. Fireban 600 is available in sheets and can also be supplied with copper cladding for making printed circuits. Sheets are approximately 37 x 49 in. in a thickness range of 0.010 to 2 in. Sheets up to 1/16 in. thickness can be cold punched.—Taylor Fibre Co.

Circle 99 on Inquiry Card for more data

Silicone Rubber

Silicone rubber cures at room temp. Catalyzed Silastic RTV 601 is poured to desired thickness and within 24 hr the RTV has set to a homogeneous, flexible silicone rubber. Thickness of cross section, degree of confinement, presence of air and moisture are claimed to have no effect on the curing rate or efficiency of cure.— Dow Corning Corp.

Circle 100 on Inquiry Card for more data

Tungsten Hexafluoride

Tungsten hexafluoride is the tungsten source for a new vapor deposition technique which permits application of tungsten coatings on complex shapes. Metallic tungsten coatings are applicable to rocket nozzles and other space equipment. —Allied Chemical Corp.

Circle 101 on Inquiry Card for more data

Epoxy Adhesive

Adhesive for bonding to steel, copper, glass and porcelain. It is said to provide bonds to aluminum exceeding 5000 psi and resist chemical attack. Called Conap 1222, the adhesive cures in one hour at 300° F.—Conap, Inc.

Circle 102 on Inquiry Card for more data

Low Temp Insulation

Urethane insulating foam is said to provide excellent structural strength and dimensional stability at sub-zero temp and exhibits a K-factor of 0.13. Density is 2.0 lb/cft. Pour-in-place foam is called H-602 Nopcofoam.—Nopco Chemical Co.

Circle 103 on Inquiry Card for more data

Ceramic Composites

Ceramic-metal composites are available on a limited-production basis. Ceramic component of Nucerite can be applied on a production basis to equipment which has a simple shape, uniform cross-section and no sharp corners. A variety of substrate metals can be used. High

temp corrosion resistance—between 500° and 1500°F; impact, erosion and abrasion resistance are claimed for Nucerite.—Pfaudler Permutit

Circle 104 on Inquiry Card for more data

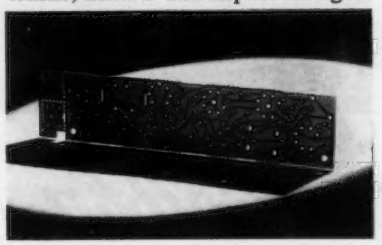
Coating Process

New process for the application of beryllium oxide protective coatings to nuclear fuel materials has been developed. A coating of nonporous beryllia is deposited on small particles of uranium dioxide in layers, up to 100 microns on 100 micron diam particles. In nuclear research and reactor applications, coated nuclear fuel particles promise major improvements in fuel element design.—Nuclear Materials & Equipment Co.

Circle 105 on Inquiry Card for more data

Printed Circuit Laminate

Copper-clad laminate for printed circuitry is said to provide high tensile, flexural and impact strength.



Material is self-extinguishing and can be cold-punched at room temp. —Cimastra Div., Cincinnati Milling Machine Co.

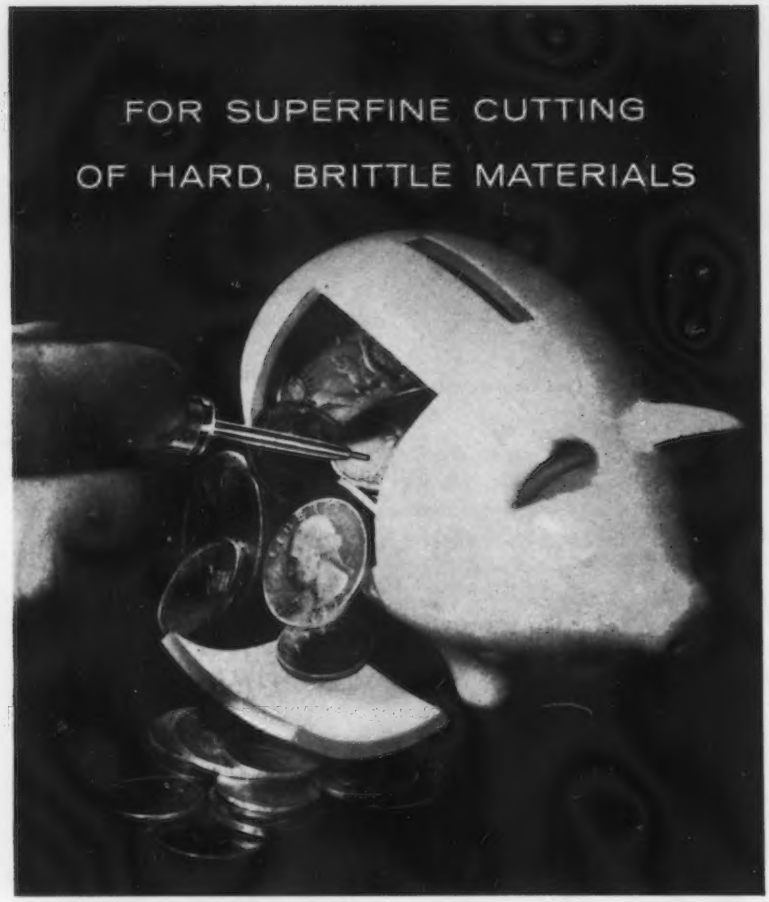
Circle 106 on Inquiry Card for more data

Light Source In Metal

New facilities will permit production of electroluminescent panels in metal, as well as in glass and plastic. Electroluminescent devices are flat panels of glass, metal, or plastic with an electrical conductive film. They are coated with a special phosphor. When a voltage is applied, the panels glow. In the case of metal panels, the metal itself conducts electricity. Metal panels can be produced in sizes up to two ft square. — Westinghouse Electric Corp.

Circle 107 on Inquiry Card for more data

continued on page 66



THE S. S. White Industrial Airbrasive® Unit

There may be easier ways to tap junior's piggy bank... but none that could craftily slice a piece out of a fragile ceramic part the way Industrial Airbrasive can.

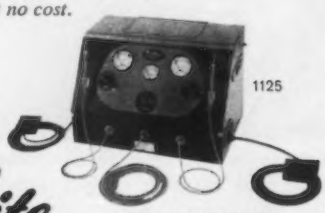
The secret of the Airbrasive's ability to cut hard, brittle materials is its accurate stream of gas-propelled abrasive. The cutting action is cool and completely shockless. Highly flexible in use, the same tool will make a cut as fine as 0.003" or it will frost, abrade or clean a large area.

Every day new uses are being found for the Airbrasive in production lines and in the laboratory... deburring small parts... shaping, drilling or cleaning germanium and other crystals... wirestripping potentiometers... removing fine films... printed circuits... micromodules... and many others!

Important too; the cost is low... for under $1,000 you can set up your own Airbrasive cutting unit!

Send us your most difficult samples and we will test them for you at no cost.

SEND FOR
BULLETIN 6006
... complete information.



S. S. White

New dual Model D!

S. S. White Industrial Division Dept. 18A 10 East 40th Street, New York 16, N. Y.

New Materials

. . . *continued from page* 65

Pyrolytic Graphite

Company has pyrolytic graphite available in plates, cylinders and special shapes. The material is produced as a coating for plain graphite and other materials, or free-standing, in sizes up to 4½ ft. Newest claim for material is that it will polarize infra-red light.—General Electric Co.

Circle 108 on Inquiry Card for more data

Bearing Grease

High/low temp ball roller bearing grease filtered to 10 or 45 microns is supplied in ½ oz syringes with needles. Primary application of the product is in the regreasing

of permanently sealed bearings. The syringe packaging virtually eliminates handling contamination. — Bearing Inspection, Inc.

Circle 109 on Inquiry Card for more data

Epoxy Resin

Epoxy resin was developed to help meet handling problems encountered in the filament winding process. Designated Bakelite epoxy ERL—0500, the resin has a built-in tertiary amine catalyst and a viscosity of 2000-4000 cps at room temp. High cure temp are said to have no detrimental effect on ERL —0500 filament wound structural properties.—Union Carbide Plastics Co.

Circle 110 on Inquiry Card for more data

Clad Metals

Line of clad metals and materials, have been incorporated into

a complete marketing package, together with design and application engineering assistance, and are being offered for consideration in value analysis studies, redesigning projects, and the creation of new products. Multilayer material is available in approximately 600 different combinations.—Metals & Controls Inc.

Circle 111 on Inquiry Card for more data

Copper-Clad Laminate

Copper-clad epoxy paper-base laminated plastic for printed-circuit

manufacturing is designated Phenolite Grade EP-492-1. Average values of 1/16 in. thick specimens of the base material are based on ASTM and other test methods. Fluxural strength lengthwise is 25,000 psi, crosswise 23,000 psi.—National Vulcanized Fibre Co.

Circle 112 on Inquiry Card for more data

Rocket-Fuel Hose

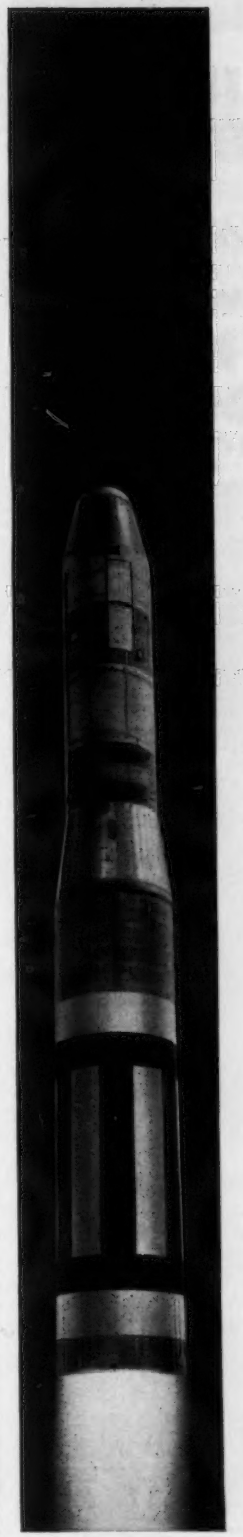
Hose designed for the Saturn permits engineers to gauge within one-tenth of a gallon the amount of fuel dispensed. A specially designed inner wire helix permits flexibility and also protects against collapse of the hose under vacuum. A rubber innertube that offers resistance to the powerful fuels and an outer cover of oil-and-weather-resistant stock complete the special hose.—Goodyear Tire & Rubber.

Circle 113 on Inquiry Card for more data

Plastisol Resin

Resin for making plastisols has low fusion temp. Called Geon 135, the new material is a polyvinyl chloride copolymer. Fusion temp for plastisols based on the new resin is 300°F. Geon 135 lowers Brookfield viscosity and yield value and improves viscosity aging. Geon 202,

continued on page 68



GOING UP WITH RCA TITAN PROJECT

RCA Titan Project, Marysville, California, has a limited number of openings for experienced Missile Engineers willing to step *up* to RCA. Openings exist at all levels in these engineering areas:

- FUELING AND PROPULSION
- MECHANICAL EMPLACEMENT
- STANDARDS, SAFETY, QUALITY
- LAUNCH CONTROL AND CHECKOUT
- ELECTRO-MECHANICAL INTEGRATION

If you are a qualified Missile Engineer and would like more information about the challenge and benefits awaiting you at the RCA Titan Project: (a) circle your professional area above; (b) check the items of information desired below; (c) attach a resume of your professional accomplishments to this ad and mail today.

If you wish, feel free to send your resume or request an application from the address below.

Please send more information about:

—— Rapid advancement opportunity in my professional area circled above.
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New Materials

. . . continued from page 67

427 or 428 can be blended with Geon 135 to lower plastisol viscosity.—B. F. Goodrich Chemical Co.

Circle 114 on Inquiry Card for more data

Heat-Reflective Tape

Pressure-sensitive tape has heat-reflecting properties. Known as PD-455, the new tape was developed as a heat shield to protect missile components during blast-off. PD-455 has found additional use as a heat shield for wire harnesses and other vital hardware. Tape is a laminate of aluminum foil and glass cloth with a silicone adhesive.—Mystik Adhesive Products, Inc.

Circle 115 on Inquiry Card for more data

Aluminum Treatment

Combination cleaner and chemical surface treatment for aluminum is designated EX-B727-6. Translucent, organic paste is applied by

spraying, brushing or wiping. Chemical reactions which occur during drying produce an organic conversion coating on the metal surface. Rinsing off dried paste leaves surface with adhesive properties for bonding or coating. — Hughson Chemical Div., Lord Mfg. Co.

Circle 116 on Inquiry Card for more data

Thermo Plastic

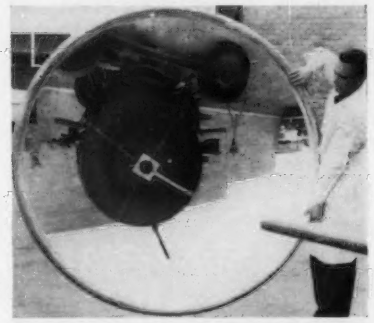
Thermo-setting plastic can be spot-magnetized to provide practically any desired pattern within a molded plastic part. The compound includes non-conductive ferrite power fillers capable of retaining either temporary or permanent magnetic charge.—Mesa Plastics.

Circle 117 on Inquiry Card for more data

New Parts and Components

Reflectors

All-metal lightweight reflecting optics for application in infrared detectors, low resolution image forming devices, solar energy collectors and radar antennas are available in diam up to 5 ft and weights from 0.4 to 1.5 lbs/sq/ft. Reflectors have aperature ratio of f/8 to f/0.4.—Electro-Optical Systems, Inc.



Circle 118 on Inquiry Card for more data

Pressure Transducer

Pressure transducer utilizes the unbounded strain gage principle with a four-active-arm spring type sensing element and a diaphragm force summing area. Pressure ranges from 0-100 psi to 0-5000 psi absolute and gage; operable temp. range is —320°F to +300°F. — Consolidated Electrodynamics Corp.

Circle 119 on Inquiry Card for more data

Quick-Disconnect Coupling

Quick-disconnect coupling with fingertip or lanyard release designed for missile applications. Couplings feature a lightweight envelop of stainless steel, and are self-sealing. Available for tube sizes from ¼ to ½ in.—Symetrics, Inc.

Circle 120 on Inquiry Card for more data

Solenoid Valve

Solenoid-operated hydraulic valve operates on 115 volts a.c. and 28 volts d.c. without adjustment or coil changes. Components can operate at nominal system pressures up to 5000 psi. Solenoid coil is hermetically sealed.—Parker Aircraft Co.

Circle 121 on Inquiry Card for more data

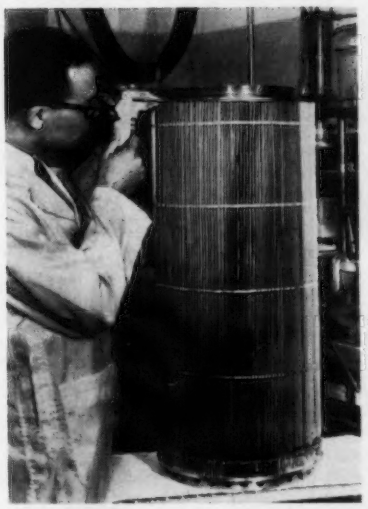
Maser Spectrometer

Developers of maser spectrometer claim that possible results growing out of electron studies through use of the spectrometer are improved rocket fuels and rocket motor casings, and lighter-weight, more effective space vehicle instrumentation. The device is made up of equipment that fills a 15 x 15 x 10 ft room. The maser spectrometer permits direct observation of effects due to unbound electrons in organic materials and the electronic spin effect of paramagnetic material.—Melpar, Inc.

Circle 122 on Inquiry Card for more data

Stainless Filter

Filter, made of stainless steel wire, was designed to strain the fuel of the supersonic B-70 bomber in flight. Unit is 38⅛ in. high. It is claimed that filter will clean out particles more than 74 microns in size.—Aircraft Porous Media, Inc.



Circle 123 on Inquiry Card for more data

Bearing Simulator

Ball bearing simulator is said to precisely reproduce the major characteristics of critical friction-easing devices. Device can be used to evaluate lubricants, contaminants and other materials and their effect on the life of bearings. The machine, a table-top device enclosed under a sealed glass cover, simulates such bearing characteristics as operating temp, atmosphere, ball-to-race contact pressure and surface speed, roll-to-spin ratio and amount and type of ball lubricant.—Sperry Gyroscope Co.

Circle 124 on Inquiry Card for more data

Filament-Wound Parts

Filament-wound reinforced plastic parts can be provided in straight tubes, closed end pressure vessels, and in tapered or other geometrical shapes. It is claimed that this material has excellent corrosion resistance and dielectric strength. Specific gravity is 2.2.—Taylor Fibre Co.

Circle 125 on Inquiry Card for more data

Limit Stop

Positive mechanical limit stop can be set for shaft revolutions from 1 to 1500 turns. Features include low starting and running torque and minimum reflected inertia, anodized aluminum encasement, with an operating speed to 1800 rpm.—Computer Sciences, Inc.

Circle 126 on Inquiry Card for more data

continued on page 70

DESIGN ENGINEERS

Inquire about new opportunities for highly qualified engineers in the fields of avionics, controls, electrical and electronics, empennage, equipment, fuselage, hydraulics, landing gear, power plant and wing design.

Requires
AE, ME, EE or related degree with aircraft or missiles experience preferred.

Combine work in an exciting professional environment with living in one of the finest cities in the country.

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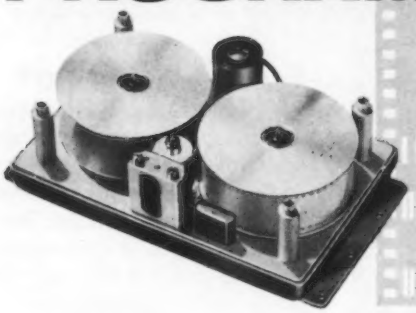

- *Missile Guidance*
- *Ground Check-out*
- *Jet Engine Testing*
- *Industrial*

13 CHANNELS — 4 HOUR PROGRAM

Where precise timing, maximum flexibility, minimum size and weight are needed in a programmer that has proved itself in numerous field applications, Beattie-Coleman MLPR13 meets all requirements. Controls programs up to 4 hrs., 42 min. duration on 13 channels. Programs quickly changed by inserting new punched 35mm Mylar tape. Reliability: 99.999%. Specified by Aerojet, Bendix, Convair, Douglas, Lockheed, Martin, North American, RCA, Ryan, Sandia and others. Send for catalog on this and other models to fit your needs.

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New Parts and Components

. . . continued from page 69

Light Weight Antenna

Antenna, composed of a lightweight rigid foam reflector and an antenna positioning device which can move the reflector through any

angle of azimuth and elevation has potential for use in satellite communication and radio and radar astronomy. Positioning device uses linear motion to support and position the reflector. Legs are long hydraulic cylinders grouped into four tripods. Coordinated changes in the length of the legs, controlled by a servo-mechanism, cause the antenna to move through desired search or track pattern.—Sylvania Electric Products, Inc.

Circle 127 on Inquiry Card for more data

Pitot-Static tube

Aerodynamically compensated pitot-static tube is said to eliminate the necessity for separate subsonic and supersonic pressure inputs to instruments. The tube's forward portion is modified by increasing the outside diameter slightly in the vicinity of the static port. The amount of increase, and the degree of taper ahead of and behind the port, will depend on aircraft nose and boom configuration.—Rosemount Engineering Co.

Circle 128 on Inquiry Card for more data

O-Seal System

System combines concepts of soft-seated valve and O-ring fitted

connections and unions, for handling liquids and gases at pressures to 6000 psi. System valves and fittings are available in standard pipe or tubing sizes from ⅛-in. to 2-in. in 6000 psi series or 1500 psi series. —Combination Pump Valve Co.

Circle 129 on Inquiry Card for more data

Semiconductor Bases

Ready-to-weld copper semiconductor bases—with integral steel rings already brazed in place are made of a special alloy with annular projection for welding. Base material is hardenable copper alloy which possesses electrical and thermal conductivity properties comparable to those of oxygen-free copper.—Standard Pressed Steel Co.

Circle 130 on Inquiry Card for more data

High Pressure Vessels

Storage vessels are designed for operating pressures up to 20,000 psi. Their applications include high pressure gaseous applications, either for airborne or ground use. The vessels are made of 4340 steel and it is claimed that they have fully undergone 100g shock tests.—AiResearch Div. Garrett Corp.

Circle 131 on Inquiry Card for more data

Temp Chamber

High-low temp chamber features ranges of —100°F to +600°F. It is claimed that temp can be lowered from +70°F to

—100°F within 5 min, and increased from 70°F to 600°F in 45 min. Electric resistance type heating unit operates on 15 amp at 115 volts a.c. Refrigerant is liquid CO_2.—Bemco Inc.

Circle 132 on Inquiry Card for more data

continued on page 72

MAJOR PROBLEM...in Propellant-Actuated Devices?

If your problem involves combining a sizeable force with light weight for positive, instantaneous operation, talk to Horkey-Moore Associates about propellant actuated devices. HMA has a wealth of experience in space vehicle applications, aircraft escape systems and ejectors for separation of airborne stores. Cartridge-actuated pin valves, pin pullers and other mechanisms can be used in many ways to accomplish a specific task. HMA's extensive facilities for engineering, manufacturing and testing are available. Call or write today.

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Circle 24 on Inquiry Card

What more do you want GRAPHITE to do for you ?

Graphite has been useful in aircraft and missile problem-solving as a component material in rocket motors, in brazing fixtures for airframe construction, and in other refractory applications.

Further and more advanced uses of graphite in space age progress may well be developing now as part of your design engineering program. We would welcome the opportunity of having our engineers, technicians and production personnel assist you in these developments.

For an introduction to the excellence of GLC graphite — and to one of the world's outstanding graphite producers — write for a free copy of our illustrated brochure, "Graphite For Diversified Industrial Applications".

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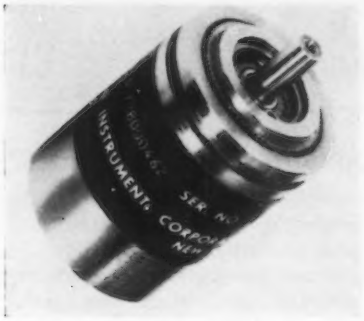
Circle 25 on Inquiry Card

New Parts and Components

. . . *continued from page* 71

Synchronous Motor

Three-fourth in. diam size 8 synchronous motor available with



or without an integral gear box, for use in computer systems, camera drives, scanning devices and other applications. 400-cycle unit measures .960 in. (ungeared), 2-5/32 in. (geared).—Kollsman Motor Corp.

Circle 133 on Inquiry Card for more data

Mini Accelerometer

Miniature Accelerometer is said to have low cross sensitivity. Model 106 Accelerometer, weighing 0.3 oz. is designed to operate from —650°F to +3600°F and is equipped with insulated mounting, hermetic connector and stainless steel case. — United Aerotronics Corp.

Circle 134 on Inquiry Card for more data

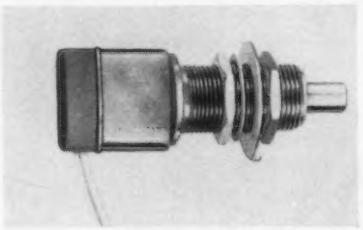
Thermoelectric Generator

Eight-watt thermoelectric power generator will operate from natural gas, propane or butane. Generators weigh 65 lb and measure 12 x 17 in. In addition to the more commonly available sources of fuel, these generators can be adapted to use any combustible fuel, waste heat and steam or solar heat.—Texas Instruments Inc.

Circle 135 on Inquiry Card for more data

Limit Switch

Hermetically sealed plunger type aircraft limit switch employs corrosion resistant material, has potted leads, and sealed plunger. Operating force is said to be 6.7 lb, release



force 3.5 lb and weight is .125 lb. —Haydon Switch, Inc.

Circle 136 on Inquiry Card for more data

Available from Stock!
NEW, INEXPENSIVE, LIGHTWEIGHT ORDNANCE CRYOGENIC COUPLINGS from FUTURECRAFT

Patent Number 2971782

Now you can replace obsolete cryogenic couplings with these new screw type units from Futurecraft—and connect flex lines, tubing or pipe quickly, easily and *safely fluid-tight.*

These couplings—service proven on Ordnance projects—are pressure rated at 150 psi operating, 300 psi proof and 450 psi minimum burst. Only low torque is required for a safe, tight seal. These Futurecraft couplings are available from stock in sizes from 1" to 4" in ½" increments, LOX cleaned and packaged. Installation tools are available.

Write for complete details

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Circle 26 on Inquiry Card

NEW, lighter weight flexible BALL joints

SIZES: 3", 4", 6", 8", 10", 12"

for **CRYOGENIC** piping

FOR PROJECT REQUIREMENTS—In handling fluid fuels and oxidizers, including liquid oxygen. Also in industrial cryogenics for liquid methane and liquid propane or butane at low, as well as ambient, temperatures.

RECOMMENDED SERVICE—(1) Fluid loading arms. (2) Expansion Joints. (3) Gimbal/Rotary Swivel motion. (4) Shock resistant flexible piping.

NEW, ADVANCED DESIGN—Has passed official "Qualification Tests," including shock tests of more than 100G's. TEMPERATURES: —320°F to +275°F. PRESSURE RATING: Designed for and qualification tested at 200 psi operating, 300 psi proof, 700 psi burst pressures. *Ask for Bulletin 233 B.* BARCO MANUFACTURING CO., 565H Hough St., Barrington, Illinois.

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Circle 27 on Inquiry Card

New Electronic Products

Detector

New electromagnetic radiation detector that weighs just under 2 lb is now available. Designed for hand

carrying this model B86B1 operates over a frequency range of from 400 to 10,000 mc while incorporating a single integral antenna and using standard, large capacity, mercury batteries. The unit responds to all planes of polarization—linear, left and right hand circular, random, pulsed or continuous wave. This integrates all incident energy and allows total field to be read on the meter. — Sperry Microwave Electronics Co.

Circle 137 on Inquiry Card for more data

Photoelectric Reader

A tape reader that has an approximate capacity of 500,000 bits of information in punched tape form is now available. This reader is suitable for "on-line" service in computer, communication and control applications. Data, in the form of coded hole sets, are photoelectrically read from pre-punched tape and transformed to electrical output pulses. The reading head is designed to accommodate standard 5, 6, 7 and 8 level codes punched 10 holes per inch along and across the tape. Metered tape speeds of up to 80 ips in either direction can be furnished.—Cook Electric Co.

Circle 138 on Inquiry Card for more data

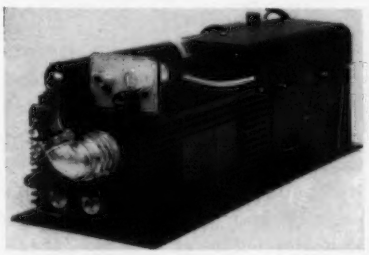
Pressure Transducer

New ultra-sensitive pressure transducer, Type BT-35, employs chemical resistant Bourdon tube coupled inductively to a differential transformer of special design. Frictionless movement provides high continuous output with good repeatability. Case construction allows external zero adjustment and easy access to all connections. Available in pressure ranges from vacuum to 10,000 psi and a temperature range of from —115 to 500 deg F.—United Aero Products Corp.

Circle 139 on Inquiry Card for more data

Radar Augmenter

A new active radar augmenter for use in electronically simulating the radar echo characteristics of small, medium and large target vehicles is now in production. The augmenter is intended for installation in drone or target aircraft to reinforce radar tracking facilities in missile carrying aircraft. Unit receives the radar-transmitted signal and transmits an amplified signal back to the aircraft—thus enabling targets of small size to appear as



large radar presentations. The augmenter weighs 14 lb and measures 16 x 4 x 5 in.—Lockheed Electronics Co.

Circle 140 on Inquiry Card for more data

Sensitive Oscilloscope

A highly sensitive oscilloscope designated Type 403-B is now commercially available. The new unit

has a sensitivity of 50 micro-volts per cm, with low noise level to permit resolution of signals as low as 10 uv. The 403-B permits display of non-amplified outputs from most strain gages, pressure pickups, accellerometers, and other transducers. It has 21 calibrated sweeps to encompass almost any recurring phenomenon or transient. — Allen B. DuMont Labs.

Circle 141 on Inquiry Card for more data

Transformer-Rectifier

Model 28VS50Y silicon transformer-rectifier unit is a static source of DC power for airborne equipment, motors and battery charging. The unit has a Y core transformer symmetrical both electrically and physically and a cooling fan that automatically regulates airflow with altitude. The unit is 4x4¼x7 in. in size and is designed to provide low ripple voltage, good regulation, continuous full output operation, and shock resistance. — Chatham Electronics.

Circle 142 on Inquiry Card for more data

continued on page 74

more trust
in the thrust
with AMAZING
BRAZING
WESTERN style!

Western Alloy's unique brazing techniques, employing super dry hydrogen and nickel brazing alloy, give maximum structural efficiency to the tubular thrust chamber pictured above, being developed at the Jet Propulsion Laboratory.

The complete thrust chamber assembly was nickel brazed in two operations at temperatures over 2000°F. in one of our hydrogen furnaces. All components brazed are 347 stainless steel.

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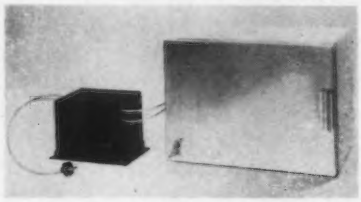
Circle 28 on Inquiry Card

New Electronic Products

. . . *continued from page* 73

Noiseless Chamber

A portable shield chamber for making electrically ultra-quiet measurements on sensitive electronic circuitry is now available. A.C.



power is supplied to any circuitry in the chamber by means of an isolation transformer unit with less than .005 mmf interwinding capacitance and more than 10,000 megohms interwinding leakage resistance. — Topaz Transformer Products, Inc.

Circle 143 on Inquiry Card for more data

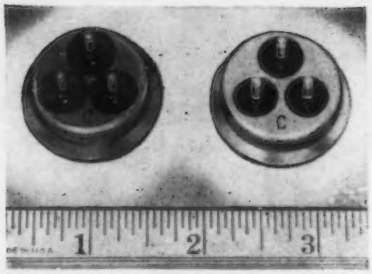
Circuit Connectors

High reliability printed circuit connectors have female contacts similar to miniaturized fuse clips. In tests these connectors were able to sustain prolonged vibration of over 40 G's from 5 to 2000 cps without circuit discontinuity. Design temperature is —60 to +450 deg F. Positive pressure and moisture seals are provided. — Matrix Science Corp.

Circle 144 on Inquiry Card for more data

Gauge Tester

Entire liquid quantity gauge systems can be tested and calibrated with one self-contained, portable instrument called "Quan Test." This model, TF-20, reduces testing time by enabling in-place or bench inspection and check out of probes, indicators and cables in capacitance-type gauge systems measuring quantity of liquid. Accuracy is assured by a single, built in, calibration for both sensing and indicating component readings. This



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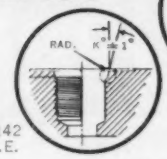
Circle 29 on Inquiry Card

Do you machine hydraulic parts?

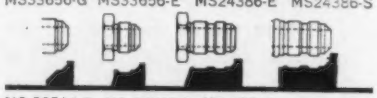
A.N.D. 10050

MS33514 or MS33515



MS 16142 or S.A.E.

MS33656-G MS33656-E MS33657-E MS24386-E MS33657-S MS24386-S



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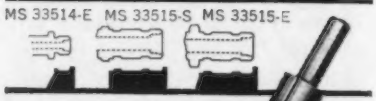


Standard cutters in stock for immediate delivery.
Write for catalog.

SONNET Tool and Mfg. Company
580 North Prairie Avenue • Hawthorne, Calif.

Circle 30 on Inquiry Card

reduces confusion that arises in dual calibration.—Consolidated Airborne Systems Inc.

Circle 145 on Inquiry Card for more data

Navigation Set

Lightweight Doppler navigation set for use in all types of aircraft from drones to supersonic jets. Set provides accurate, all weather navigation over land or sea without radio aids, wind estimates, or air speed data. The system accommodates all speed ranges from zero to plus 2000 knots and altitudes up to 70,000 feet.—Ryan Electronics

Circle 146 on Inquiry Card for more data

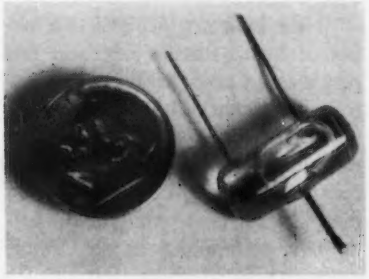
Temperature Indicator

Compact instrument for measuring and monitoring temperature incorporates a servo-driven, self balancing potentiometer type bridge system. Unit is fully transistorized and is said to give instantaneous indications with no warm up lag. Model DST-16 measures 6 in. in length and 2 in. in diameter.—Consolidated Airborne Systems, Inc.

Circle 147 on Inquiry Card for more data

Subminiature Element

A vertical sensing element of the single axis, snap action, bubble type is now in production. Model 228571-1 is an electrolytic unit which can drive torque motors directly without amplifiers. This instrument is an "on-off" snap action device that cannot be nulled, it has a tilt angle of .75 deg and an 18 volt differential output voltage with 18 ma. maximum current through



either contact. This unit has no null and operates between 75 minutes and 135 minutes of arc.—Kearfott Div. General Precision, Inc.

Circle 148 on Inquiry Card for more data

continued on page 76

COUNT DOWN

these advantages of Tayloron* Reinforced Plastics in high-performance assemblies

6 **High strength-to-weight ratio.** In terms of weight, reinforced plastics are considerably stronger than most metals. Moreover, their strength characteristics may be directed where stresses demand. In filament or tape wound shapes, highest properties may be obtained.

5 **Comparative rigidity in cured condition.** This property prevents the reinforced plastic part from bulging or otherwise deforming when high pressures or other stresses are present. Thus original tolerances can be maintained under adverse operating conditions.

4 **Excellent corrosion resistance.** High resistance to both atmospheric and chemical corrosion is a feature of reinforced plastics. This is particularly important in structural members where corrosion could generate failure locations.

3 **Low heat transfer.** This, under extremely high temperatures, makes Tayloron ideal for protecting structural members in missiles.

2 **Good ablation qualities.** The capacity to keep on performing their basic function despite loss of some of their structure is an important characteristic true of some reinforced plastics. Tayloron materials offer the additional advantages of dissipating energy and thus reducing stresses on other members.

1 **Ease of fabrication.** A wide variety of shapes may be made to close dimensions by molding, laminating, or winding of filament or tape. Tayloron reinforced plastics are readily fabricated and machined.

How Taylor Can Help You

In your designing of components and assemblies, consult our Advanced Materials Division on how to choose the best material and minimize the cost in reinforced plastics. Taylor can supply complete fabricated assemblies—or materials for any test and evaluation program. Special Tayloron materials have been developed for many specialized applications. Write the Advanced Materials Division outlining your specific problem. Taylor Fibre Co., Norristown 50, Pa.

*Trade name for Taylor Fibre's space, missile and astronautic materials

Taylor
REINFORCED PLASTICS / VULCANIZED FIBRE

Composite laminates • Metallic and nonmetallic materials laminated with plastic resins in many combinations and many forms • Vulcanized fibre in sheet, roll or fabricated parts • Filament wound parts • Materials and components engineered to perform specific functions • Pre-impregnated materials in filament, tape, wide sheet or roll

Circle 31 on Inquiry Card

New Electronic Products

. . . continued from page 75

Pulse Rate Integrator

Miniaturized integrator for use in aircraft and missiles for converting frequency to voltage for telemetering. New unit features a self contained calibrating circuit and a high-input and low-output impedance. It has a full scale of 5 volts and is adjustable over a 4 to 1 frequency range. Input sensitivity is adjustable from 10 mv to 1 volt. Integrator weighs 20 ounces and has printed circuit construction with plug-in module.—Anadex Instruments, Inc.

Circle 149 on Inquiry Card for more data

Servo Amplifier

Improved 3.5 watt servo amplifier for missile, space vehicle, aircraft and other stress environment applications is said to be 80 per cent efficient and thereby eliminates the need for a heat sink when functioning in an ambient temperature range from —55 to +125 deg C. Designed to operate from a 115 V AC line the unit is engineered for high performance under extreme conditions of shock, vibration and atmospheric contamination. — The Siegler Corp.

Circle 150 on Inquiry Card for more data

Ripple Meter

Portable meter designed to measure ripple voltage on aircraft and missile DC power supplies can also

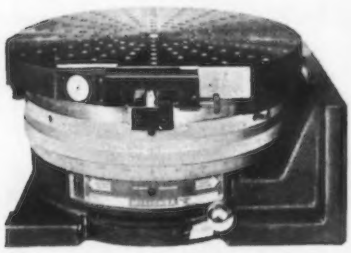
be used as a battery or line powered, transistorized volt meter. The model T256 measures—"peak to peak," "plus peaks," "minus peaks" or "rms." A large meter with color coded scales simplifies reading.—Avtron Mfg., Inc.

Circle 151 on Inquiry Card for more data

Tachometer Indicator

New indicator accepts the output of a tachometer generator and provides an accurate digital indication in per cent of full rpm. A manual digital null-balance dial covers the range of 50 per cent to 110 per cent rpm and can be read to better than 0.1 per cent rpm. Model FR-85 can be applied as a portable secondary standard for testing tach indicators and for trimming jet engines. Construction is of solid state components on printed circuit cards housed in a cast aluminum case.—Waugh Engineering Co.

Circle 152 on Inquiry Card for more data



PRECISION INDEXING TO ¼ SECOND OF ARC ACCURACY WITH ©MILICHEX ROTARY INDEXING TABLES

for machining, inspecting, grinding

MGX—3600—12″

Each Milichex is interferometer checked and certified to be within ¼ second of arc accuracy in 360°. Heart of the Milichex is a pair of meshing plates—each with 360 precision ground serrations. Upper plate rotates to desired angular setting and plates mesh into exact position upon shifting locking handle.

All 720 teeth are in positive engagement when table is locked—there is no possibility of slippage or error due to worm-gear play, etc. In use, teeth lap each other so that accuracy actually improves with wear. Model shown has optional sub-plate assembly for settings to minutes and seconds. Sine plate also available.

● **FOR SETTING TO ¼° INCREMENTS**

Double table model indexes in full or fractional angles to 15-minute increments without gage blocks. Models for 1/10 degree and other increments also available.

● **MILICHEX OPTICAL POLYGON**

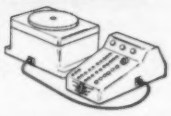
Incorporates optically flat mirror capable of being set to any full degree. Replaces any multi-sided polygon divisable into 360 degrees. Accurate to ¼ second of arc.

● **FOR SMALLER PRECISION WORK**

7″ Milichex can be used by itself or built into manufacturing or checking setup. Optional base (shown) permits use horizontally or vertically.

● **AUTOMATED FOR REMOTE OPERATION**

Remote control console models with digital readouts . . . allows automatic indexing to any angle or push-button indexing a preset number of degrees.



MICHIGAN TOOL COMPANY
7171 E. McNICHOLS ROAD, DETROIT 12, MICHIGAN

New for Production

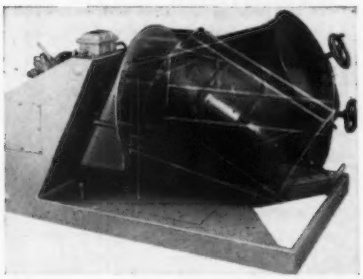
Semiconductor Furnace

A crucible pot furnace with atmosphere retort and forced air cooling pit is said to be ideal for glass to metal sealing and heat treatment of metals. Type RDPC-77 furnace is rated at 2250°F max chamber temperature. Chamber is 7 in. diameter by 7 in. deep. Atmosphere retort has a working area of 4½ in. dia. by 6½ in. deep and can be used to 2150°F. Cooling of the retort is obtained by a non-insulated forced air cooling pit.—Lindberg Engineering Co.

Circle 153 on Inquiry Card for more data

Drum Mixer

Machine uses a rotary oscillating motion for mixing 55 gallon drums weighing up to 1,000 lbs. Unit is said to mix difficult materials such as sound deadener, glazing compound, abrasives, and plastics in a relatively short time. One



man can operate the machine by rolling a drum into position on the cradle where hydraulic jacks raise and center it for mixing.—National industries

Circle 154 on Inquiry Card for more data

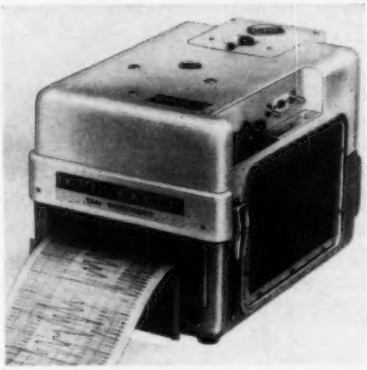
Torque Wrench

A remembering wrench for making mechanical checks of stress, strain, thrust, tension and compression where a record of the peak reading is desired. The wrench has a memory pointer that is pushed along a track on the face of the scale as torque is exerted. The pointer remains pointing at the peak torque exerted after pressure is released.—P. A. Sturtevant Co.

Circle 155 on Inquiry Card for more data

Oscillograph

A direct reading oscillograph with an optional built-in flash tube timer that produces full-width time



lines on recording paper at any of three intervals. Called the Visicorder, it employs a timing circuit that can be triggered externally by supplying pulsing voltage of 10v at 20K ohms impedance or by causing impedance to drop to 100 ohms or less. Manufacturer claims that the Visicorder can record as many as 14 channels of test data simultaneously, each at frequencies up to 5,000 cycles per sec.—Minneapolis-Honeywell Regulator Co.

Circle 156 on Inquiry Card for more data

Dual Stripper

Model WS17B, thermal wire stripper has two push-button stripper handles operating from the same power source, this allows two operators to work side by side or across from each other. Unit handles wire from #6 to #36 with teflon, nylon or other plastic insulation.—American Missile Products.

Circle 157 on Inquiry Card for more data

Midget Grinder

Designed for precision tool and die grinding this pneumatically operated grinder is available with either 38,000 or 60,000 rpm motors. Kit contains a grinder, four mounted points, a carbide mill, wrenches, whip hose and a plastic case. Several models are available with muffled motors.—Airetool Mfg. Co.

Circle 158 on Inquiry Card for more data

Electrochemical Process

A process known as Electrochemical machining permits stress free machining of complex contours in any metal, including the refractory alloys. The ECM process is essentially the reverse of electroplating. The work piece and a "cutting-tool" shaped like the desired part serve as electrodes. A high amperage direct current is passed through the piece to the tool through an electrolyte, shaping the raw stock into the finished product. —Hanson-Van Winkle-Munning.

Circle 159 on Inquiry Card for more data

Portable Divider Head

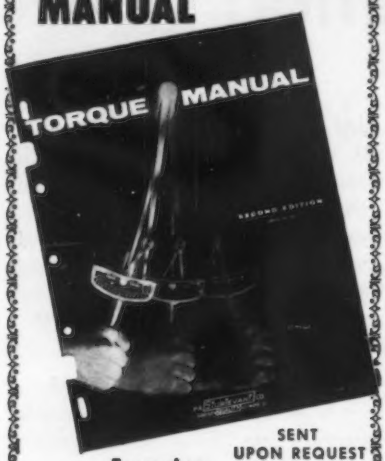
Divider head which checks angular measurements on rotating components is said to have an accuracy of ±15 seconds. A dial indicator gives direct angular readings with a 3 second resolution. Unit is constructed of tool steel and will

accommodate conponents with a diameter of ¾ in. to 2½ in.—Gertsch Products, Inc.

Circle 160 on Inquiry Card for more data

continued on page 78

"TORQUE WRENCH" MANUAL



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TOTAL TEMPERATURE PROBES
PITOT-STATIC TUBES

ILLUSTRATED MODELS

MODEL 850 Meets Mach 3 requirements of MIL-P-25757A (USAF).

MODEL 103 Mach 5 total temperature probe can be used to temperatures of 1500 C°.

MODEL 101 Mach 3 total temperature probe. Meets requirements of MIL-P-25726 (USAF).

MODEL 102 Mach 3 Deiced total temperature probe. Accurately measures total temperature during deicing.

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ROSEMOUNT ENGINEERING COMPANY
4912 West 78th St.
Minneapolis 24, Minn.

Circle 34 on Inquiry Card

New for Production

. . . *continued from page 77*

Programmed Drill

A program drill with a mechanical programming operation that can be set up by unskilled personnel. Unit automatically drills any preselected pattern of holes up to 200 in number through a load of one or more printed circuit boards up to 8 x 12 in. size. Drill consists of a high-speed, electric motor with a pneumatically operated spindle and a movable work table controlled by a "program" of paired stop pins set in a revolving control disk. Programming is accomplished by setting a pair of pins for each hole desired. — Develop-Amatic Engineering

Circle 161 on Inquiry Card for more data

Liquid Lathe

A machine which resembles a cannon delivers a needle point of liquid under thousands of pounds of pressure to cut through materials such as cement, wood and plastic. One market for the new concept is in removing high energy solid propellant materials from engine casings. Models for cutting and shaping metals are now under development. — Abrasi-Jet Machine Tool Corp.

Circle 162 on Inquiry Card for more data

Arc Welding

Two part welding package consists of a AH20-E MIGet gun and a MIGet CAV power source. The gun connects directly to the power source where a knob sets the arc voltage and a knob on the gun adjusts the wire feed speed. Manufacturer claims that the gun can be used for making numerous short length welds as far as fifty feet from the power source.—Air Reduction Sales Co.

Circle 163 on Inquiry Card for more data

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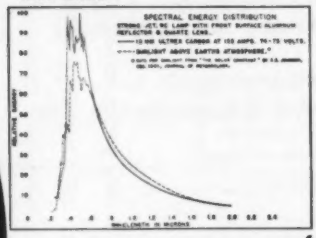
Useful radiation is efficiently collected by first surface reflectors and concentrated at the reimaging point from where it can be projected by a quartz objective system in a pattern shaped to fit the work area. A circular radiation pattern totals 374 watts with an 80% uniformity of field or a total of 668 watts with a 60% uniformity of field. Higher or lower energy unit areas, can be obtained by variation in optics or projection distance. Large areas can be covered by multiple employment of lamps using either superimposed or overlapping pattern technique. Other, less powerful carbon arc sources, are also available for smaller work areas.



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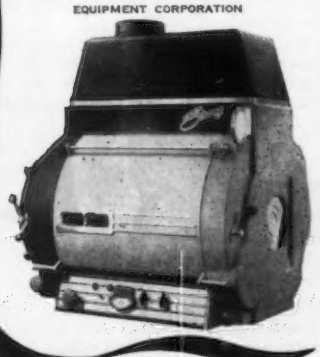

Circle 37 on Inquiry Card

Freezing Standards

Freezing point determination apparatus is furnished with National Bureau of Standards freezing point samples. Samples include tin, lead, aluminum, zinc, copper and

gold which are contained in hermetically sealed graphite crucibles. Designed to test temperature sensing devices the unit features a rapid warm up with a freeze out time of from 15 to 20 minutes.—Temptron, Inc.

Circle 164 on Inquiry Card for more data

Thermal Concrete

Heat-resistant concrete, designed to withstand supersonic shock and erosion, is available for flame deflectors at missile launch and test facilities. Fondu Fyre is a combination of refractory aggregates and a hydraulic setting binder. It can be placed by guniting or pouring, and is ready for firing in 24 hr.—Designed Concretes Co.

Circle 165 on Inquiry Card for more data

Radiation Fuel Gauge

Transistorized radiation gauge measures fuel in tank. Lightweight gage consists of radioisotopes and detector units mounted outside the fuel tanks. Gamma rays from the isotopes pass through the tanks. The intensity of the rays reaching the detectors indicates the amount of fuel.—Atomics International.

Circle 166 on Inquiry Card for more data

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New high pressure, in-line, relief valves with low hysteresis

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Douglas Aircraft Company is part of the Army Ordnance-industry team developing the Nike Zeus Anti-missile System. Western Electric Company is the industrial prime contractor.

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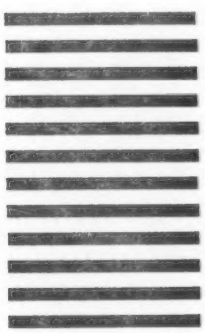

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YOUR NAME .....TITLE .....

COMPANY .....

PLANT ADDRESS .....

CITY .....ZONE.....STATE.....

MUST INFORMATION

Please check in A & B below (one each) which best describes:

A. Your Job Function

....1. Management
....2. Design & Engineering
....3. Production
....4. Procurement

B. Type of Plant or Facility

....1. Airframe
....2. Propulsion
....3. Electronic Systems & Parts
....4. Mechanical Systems & Parts
....5. Raw & Processed Material
....6. Engineering & Research Services
....7. Military & Government Facilities
....8. Parts & Supplies
....9. Plant or Test Equipment
....0. Other

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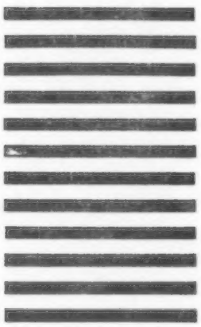

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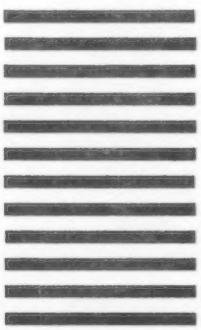

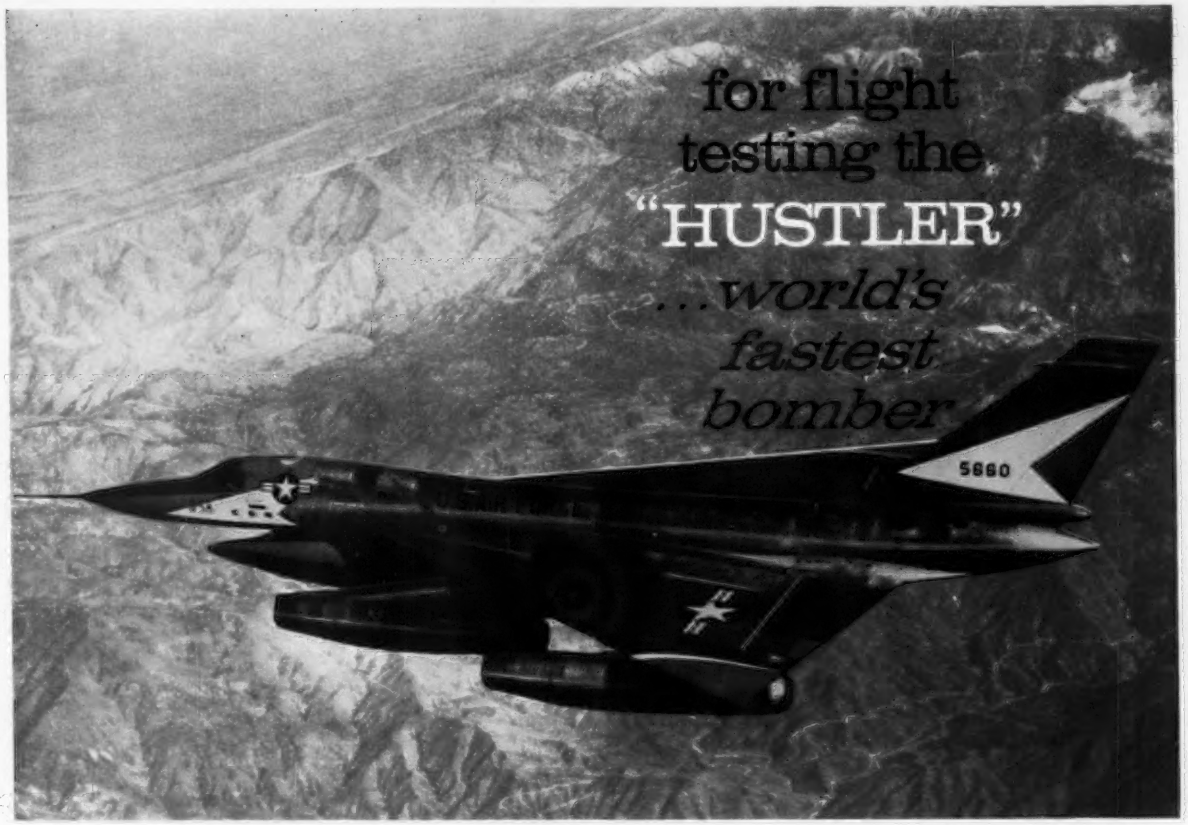

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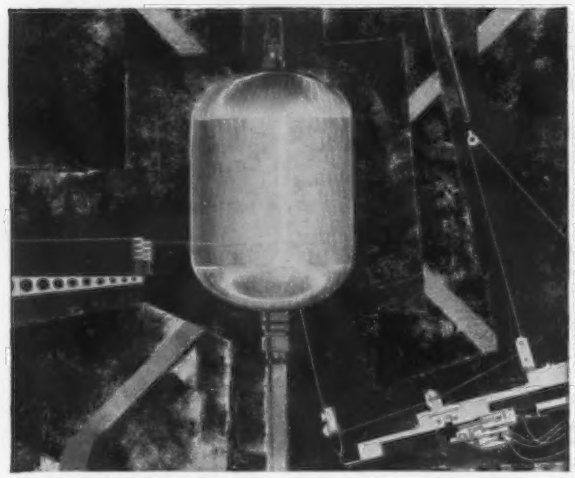

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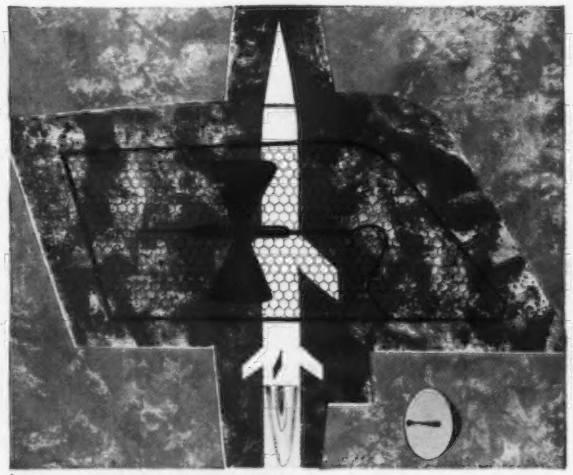

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